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⑳ Electrical wiring block with break test capability.

⑷ An electrically balanced wiring device (100) comprises first and second rows (110 and 112) of connector blocks (108) including beam contacts for transmission lines. A row (116) of connecting strips (114) is located between the first and second rows (110 and 112) of connector blocks (108). The connecting strips (114) include a first and second set of contacts co-operating to define defeatable electrical connections in said connecting strips. The connector blocks (108) and connecting strips (114) are mounted on a circuit board (106). A circuitry on the circuit board (106) connects the contacts of the connector blocks in the first row (110) to the contacts of the first set in the connecting strips (114) and the contacts of the connector blocks in the second row (112) to the contacts of the second set in the connecting strips (114). The circuitry on the circuit board (106) is configured so as to substantially restore electrical balance to the transmission lines wherein cross talk originating from said first and second connector means is reduced.

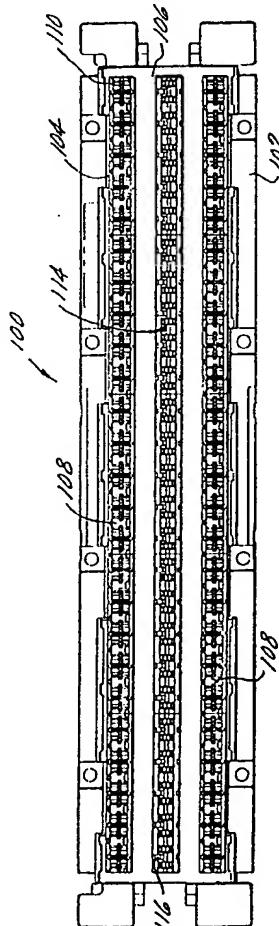


FIG. 1A

This invention relates to wiring blocks for use primarily in the communications industry. More specifically, this invention relates to a wiring device with break test capability.

Communication system and/or network efficiency is directly dependent upon the integrity of the connector scheme employed. Such connector schemes include, for example, standard interfaces for equipment/user access (outlet connector), transmission means (horizontal and backbone cabling), and administration/distribution points (cross-connect and patching facilities). Regardless of the type of capabilities of the transmission media used for an installation, the integrity of the wiring infrastructure is only as good as the performance of the individual components that bind it together.

By way of example, a non-standard connector or pair scheme may require that work area outlets be rewired to accommodate a group move, system change, or an installation with connecting hardware whose installed transmission characteristics are compatible with an existing application but are later found to have inadequate performance when the system is expanded or upgraded to higher transmission rates. Accordingly, connecting hardware without properly qualified design and transmission capabilities, can drain user productivity, compromise system performance and pose a significant barrier to new and emerging applications.

Reliability, connection integrity and durability are also important considerations, since wiring life cycles typically span periods of ten or twenty years. In order to properly address specifications for, and performance of telecommunications connecting hardware, it is preferred to establish a meaningful and accessible point of reference. The primary reference, considered by many to be the international benchmark for commercially based telecommunications components and installations, is standard ANSI/EIA/TIA-568 (TIA-568) Commercial Building Telecommunications Wiring Standard. A supplement Technical Systems Bulletin to TIA-568 is TIA/EIA TSB40 (TSB40), Additional Transmission Specifications for Unshielded Twisted-Pair Connecting Hardware. Among the many aspects of telecommunications cabling covered by these standards are connecting hardware design, reliability and transmission performance. Accordingly, the industry has established a common set of test methods and pass/fail criteria on which performance claims and comparative data may be based.

To determine connecting hardware performance in a data environment, it is preferred to establish test methods and pass/fail criteria that are relevant to a broad range of applications and connector types. Since the relationship between megabits and megahertz depends on the encoding scheme used, performance claims for wiring components that specify bit rates without providing reference to an industry stan-

dard or encoding scheme are of little value. Therefore, it is in the interest of both manufacturers and end users to standardise performance information across a wide range of applications. For this reason, application independent standards, such as TIA-568 and TSB40 specify performance criteria in terms of hertz rather than bits per second. This information may then be applied to determine if requirements for specific applications are complied with. For example, many of the performance requirements in the IEEE 802.3i (10BASE-T) standard are specified in megahertz (MHz), and although data is transmitted at 10 Mbps for this application, test "frequencies" are specified in the standard (as high as 15 MHz).

Transmission parameters defined in TSB40 for unshielded twisted pair (UTP) connectors include attenuation and near-end crosstalk (NEXT) and return loss.

Connector attenuation is a measure of the signal power loss through a connector at various frequencies. It is expressed in decibels as a positive, frequency dependent value. The lower the attenuation value, the better the attenuation performance. Since connecting hardware is generally considered to be electrically short relative to the length of cabling between two active devices (i.e., up to 100 meters of cable is typically allowed), the attenuation performance of the connecting hardware is usually not a major performance consideration.

Connector crosstalk is a measure of signal coupling from one pair to another within a connector at various frequencies. Since crosstalk coupling is greatest between transmission segments close to the signal source, near-end crosstalk (as opposed to far-end) is generally considered to be the worst case. Although measured values are negative, near-end crosstalk (NEXT) loss is expressed in decibels as a frequency dependent value. The higher the NEXT loss magnitude, the better the crosstalk performance.

Connector return loss is a measure of the degree of impedance matching between the cable and connector. When impedance discontinuities exist, signal reflections result. These reflections may be measured and expressed in terms of return loss. This parameter is also expressed in decibels as a frequency dependent value. The higher the return loss magnitude, the better the return loss performance.

Since most high speed transmission applications that are designed for use with twisted-pair cabling do not operate in a full duplex mode (i.e., transmit and receive signals are not carried over the same pair), the effects of signal reflections, as caused by connectors, are generally not significant with respect to the ability of the twisted pair cabling. However, for future high speed applications that may employ full duplex transmission, connector return loss poses a significant limitation unless properly controlled.

The net effect of these parameters on channel performance may be expressed in signal-to-noise ratio (SNR). For connecting hardware, the parameter that has been found to have the greatest impact on SNR is near-end crosstalk.

Several industry standards specify multiple performance levels of UTP cabling components have been established. For example, Category 3, 4 and 5 cable and connecting hardware are specified in EIA/TIA TSB-36 & TIA/EIA TSB40 respectively. In these specifications, transmission requirements for Category 3 components are specified up to 16 MHz. They will typically support UTP voice and IEEE 802 series data applications with transmission rates up to 10 Mbps, such as 4 Mbps Token Ring and 10BASE-T.

Transmission requirements for Category 4 components are specified up to 20 MHz. They will typically support UTP voice and IEEE 802 series data applications with transmission rates up to 16 Mbps, such as Token Ring.

Transmission requirements for Category 5 components are specified up to 100 MHz. They are expected to support UTP voice as well as emerging video and ANSI X3T9 series data applications with transmission rates up to 100 Mbps, such as 100 asynchronous transfer mode (ATM) applications.

In order for a UTP connector to be qualified for a given performance category, it must meet all applicable transmission requirements regardless of design or intended use. The challenge of meeting transmission criteria is compounded by the fact that connector categories apply to worst case performance. For example, a work area outlet that meets Category 5 NEXT requirements for all combinations of pairs except one, which meets Category 3, may only be classified as a Category 3 connector (provided that it meets all other applicable requirements).

Wiring/connector blocks with circuit interrupt capability, sometimes referred to as "break-test" capability, are well known. For example, such products are described in U.S. Patent Nos 5,044,979; 4,547,034 and 4,615,576. These patents describe wiring/connector blocks having two rows of wire termination connectors that are separated by an optional connector for providing interruptable electrical connections between the two rows of wire termination connectors. An important limitation of these prior art blocks is that the spatial alignment of the adjacent contacts allows crosstalks coupling to occur within the connector between the input and output terminations.

The regular clip spacing causes uniform capacitive coupling between adjacent rows of clips such that, when used with twisted-pair wires, the "tip" and "ring" wires that constitute a pair (balanced transmission line) is equal to that of adjacent conductors from different pairs. Since the crosstalk performance is determined by the degree of capacitive imbalance be-

tween pairs (i.e. the difference in capacitive coupling between each conductor of a pair and a conductor of another pair), the constant spacing between rows poses a limitation in terms of crosstalk performance between adjacent circuits. The extent of this limitation is manifested in terms of transmission performance. Transmission tests of these ability to support high speed signalling applications is limited to those supported by cabling systems of Category 4 or less.

AT&T Technologies 110T-series terminal block employs two rows of known 100C series connecting blocks with its bottom insulation displacement terminals connected to bent tail leads that extend from contacts positioned between the two rows of 110C connectors. These contacts are positioned and housed to provide a circuit interrupt capability. As with the devices described in U.S. Patent Nos. 5,044,979; 4,547,043 and 4,615,576, the regular contact spacing and significant electrical length of this product have the effect of limiting transmission performance, and hence its ability to support advanced networking applications. In this case, transmission performance is limited to Category 4.

U.S. Patent No. 5,160,273 discloses a "break-test" device which employs positioned shielding to improve crosstalk isolation between pairs. Although this design provides a benefit in terms of improved cross-talk performance over the above discussed prior art devices, it is bereft with other limitations such as by additional expense of the shield element and numerous additional secondary operations required to assemble the finished product. The shield also raises the risk of compromising electrical isolation between signal carriers.

Prior art methods also exist for achieving electrical balance between pairs to improve crosstalk performance of other types of connectors used with balancing cabling. In particular, EP-A-0602484, filed 4 December 1993, discloses an electrically balanced connector assembly for modular jack outlet connectors. However, modular jack outlet connectors do not require internal "break-test" capability. Heretofore wiring blocks have not offered compensation means to achieve electrical balance between pairs.

It is an object of this invention to provide an electrically balanced wiring device that overcomes or alleviates the above discussed drawbacks and deficiencies of the prior art.

This problem is solved by a wiring device according to claim 1.

The electrically balanced wiring device or block assembly of this invention has a circuit board which includes impedance controlled circuitry with integrally defined capacitive elements designed to improve electrical balance between interconnected wiring and connecting strips and thereby optimise its transmission performance.

Plated through-holes in said circuit board are pre-

ferably used for integrally defining capacitive elements. The traces of said circuitry are sized and spaced to provide a given characteristic impedance that is designed to match that of the balanced cable to which it is connected (typically 100 ohms). This impedance controlled circuitry is connected to the capacitive through-holes that are sized, spaced and interconnected in various configurations to generate the desired capacitance. This method of tuning capacitive balance between pairs of contacts makes use of the proportioning of the printed circuitry elements to produce a new desired effect.

An extremely repeatable and economical means of adding capacitance to electrical circuits is also disclosed.

The two rows of connecting blocks and the row of connecting strips therebetween are mounted to one side of the circuit board preferably by solderless means and are interconnected between selected leads of the connecting blocks and connecting strips by the circuitry such that, when it is interrupted by insertion of a patch connector or test adapter, the appropriate amount of compensation still exists for the two circuits that extend between the wire termination and center connecting strips as a result of separating the "break-test" contacts.

The circuit board is preferably mounted onto a bracket which is itself mounted onto a wiring block base.

A disconnect plug is provided for breaking electrical connection between selected connecting block positions by separating contacts at selected connecting strip positions. The plug includes an insulated dividing member which is inserted between the selected connecting strip contacts. The plug and strip housing further include means for aligning and retaining the plug on the connecting strip. The strip housing and disconnect plug are designed such that circuits may only be interrupted in one pair increments. Insertions at the plug between pairs (i.e., and ring of adjacent pairs) is prevented.

Also, a modular jack test assembly is provided for testing and/or at other times when modular jack connection is desired. The modular jack test assembly comprises a modular jack mounted on a circuit board having edge contacts for mating with the contacts of the connecting strip. The modular jack and circuit board are enclosed in a housing assembly which includes means for aligning and retaining the modular jack test assembly on the connecting strip. The strip housing and test plug are designed such that the circuit may only be accessed in increments of one pair. They also include polarity features to ensure that the plug can only be inserted when oriented one way. All keying and polarity features are designed to prevent access to the center contacts unless the test plug is properly aligned and oriented. The printed circuit board with the modular jack may also include integral-

ly defined capacitive elements designed to improve electrical balance between the modular jack and the edge contacts on the circuit board and thereby optimise its crosstalk performance.

5 Devices that are electrically short relative to the wavelength of the signals they are intended to carry are commonly modelled as discrete (or lumped) elements. Since the maximum frequency used to characterise connecting hardware for twisted-pair cabling is 100 MHz as defined in TSB40, components whose electrical length is less than one-eighth the signal wavelength at this frequency may be treated as a single electrical entity, rather than a series of discrete elements. For example, a 100 MHz signal has a wavelength (λ) of approximately 3 meters, therefore the properties of the individual components that a connector is composed of (i.e., wire termination means, break-test means, and printed circuitry), behave as a single electrical entity, provided that the total electrical length between input and output connections does not exceed $3 \text{ meters} + 8 = 38 \text{ cm}$.

10 The fact that the properties of the individual elements of a connector exhibit an "averaging" effect permits the introduction of electrical compensation means, such that the adverse electrical properties of one portion of the connector, may be offset by the introduction of appropriate reactive compensation means in another. In the case of the present invention, printed circuitry is used in a novel way to compensate for impedance discontinuities and capacitive imbalance caused by the wire connection means and break test means that are connected thereto.

15 The above-discussed and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description and drawings.

20 Referring now to the drawings wherein like elements are numbered alike in the several figures :

25 Figures 1A-C are views of a wiring block in accordance with the present invention wherein Figure 1A is a top plan view thereof, Figure 1B is a side elevational view thereof, and Figure 1C is an end view thereof;

30 Figures 2A-B are views of a base used in the wiring block of Figures 1A-C wherein Figures 2A is a top plan view thereof and Figure 2B is an end view thereof;

35 Figures 3A-E are views of a bracket used in the wiring block of Figures 1A-C wherein Figure 3A is a top plan view thereof, Figure 3B is a side elevational view thereof, Figure 3C is an end view thereof, Figure 3D is a bottom view thereof, and Figure 3E is a view taken along the line 3E-3E of Figure 3D;

40 Figures 4A-C are views of a circuit board used in the wiring block of Figures 1A-C wherein Figure 4A is a top view thereof, Figure 4B is a side elevational view thereof, and Figure 4C is a bottom

view thereof;

Figure 4D is a schematic of the capacitive compensation means employed by the present invention;

Figure 4E is a schematic of the impedance matching means employed by the present invention;

Figure 5 is a side elevational partly cross sectional view of a connecting block mounted on a circuit board, partially shown, used in the wiring block of Figures 1A-C;

Figures 6A-D are views of a connecting strip used in the wiring block of Figures 1A-C wherein Figure 6A is a side elevational view thereof, Figure 6B is a top view thereof, Figure 6C is an end view thereof, and Figure 6D is a view in partial cross-section taken along the line 6D-6D of Figure 6A;

Figures 7A-G are views of a housing used in the connecting strip of Figures 6A-D wherein Figure 7A is a side elevational view thereof, Figure 7B is a top view thereof, Figure 7C is a bottom view thereof, Figure 7D is a view taken along the line 7F-7F of Figure 7A, and Figure 7G is a view taken along the line 7G-7G of Figure 7A;

Figures 8A-D are views of a contact used in the connecting strip of Figures 6A-D wherein Figure 8A is a side elevational view thereof, Figure 8B is an end view thereof, Figure 8C is a view taken along the line 8C-8C of Figure 8A, and Figure 8D is a view taken along the line 8D-8D of Figure 8A;

Figures 9A-D are views of the wiring block of Figures 1A-C without the base of Figures 2A-B wherein, Figure 9A is a top plan view thereof, Figure 9B is a side elevational view thereof, Figure 9C is an end view thereof, and Figure 9D is a view in partial cross section taken along the line 9D-9D of Figure 9B;

Figures 10A-C are views of the wiring block in accordance with an alternate embodiment of the present invention wherein Figure 10A is a top plan view thereof, Figure 10B is a side elevational view thereof in partial cross-section and Figure 10C is an end view thereof;

Figures 11A-E are views of a disconnect plug for use with the connecting strip of Figures 6A-D in accordance with the present invention wherein Figure 11A is a side elevational view thereof, Figure 11B is a first end view thereof, Figure 11C is a second end view thereof in partial cross-section, Figure 11D is a view taken along the line 11D-11D of Figure 11C, and Figure 11E is a view taken along the line 11E-11E of Figure 11B;

Figures 12A-D are views of a first portion of a cover assembly in accordance with the present invention wherein Figure 12A is an exterior side elevational view thereof, Figure 12B is an end view thereof, and Figure 12D is an interior side elevational view thereof;

Figures 13A-E are views of a second portion of the cover assembly in accordance with the present invention wherein Figure 13A is an interior side elevational view thereof, Figure 13B is an end view thereof, Figure 13C is a view taken along the line 13C-13C of Figure 13A, Figure 13D is an exterior side elevational view thereof, and Figure 13E is a view taken along the line 13E-13E of Figure 13A;

Figures 14A-C are views of a modular jack mounted on a circuit board in accordance with the present invention wherein Figure 14A is a side elevational view thereof, Figure 14B is an end view thereof, and Figure 14C is a top view thereof;

Figures 15A-C are views of a circuit board of Figures 14A-C wherein Figure 15A is a first side view thereof, Figure 15B is an end view thereof, Figure 15C is a second side view thereof, and Figure 15D is a schematic of the electrical connections thereof;

Figures 16A-D are views of the circuit board of Figures 14A-C in accordance with an alternate embodiment wherein Figure 16A is a first side view thereof, Figure 16B is an end view thereof, Figure 16C is a second side view thereof, and Figure 16D is a schematic of the electrical connections thereof;

Figures 17A-D are views of the circuit board of Figures 14A-C in accordance with an alternate embodiment wherein Figure 17A is a first side view thereof, Figure 17B is an end view thereof, Figure 17C is a second side view thereof and Figure 17D is a schematic of the electrical connections thereof;

Figures 18A-D are views of the circuit board of Figures 14A-C in accordance with an alternate embodiment wherein, Figure 18A is a first side view thereof, Figure 18B is an end view thereof, Figure 18C is a second side view thereof, and Figure 18D is a schematic of the electrical connections thereof;

Figures 19A-D are views of the modular jack and circuit board of Figures 14A-C installed within the cover assembly of Figures 12A-D and 13A-E in accordance with the present invention wherein Figure 19A is a side elevational view thereof, Figure 19B is an end view thereof, Figure 19C is a bottom view thereof, Figure 19D is a top view thereof, and Figure 19D is a schematic of the electrical connections thereof;

Figures 20A-D are views of a modular jack with a circuit board installed in a cover assembly in accordance with an alternate embodiment of the present invention wherein Figure 20A is a side elevational view thereof, Figure 20B is an end view thereof, Figure 20C is a bottom view thereof, and Figure 20D is a top view thereof;

Figures 21A-E are views of a first portion of the cover assembly of Figures 20A-D wherein Figure 21A is an exterior side elevational view thereof, Figure 21B is a view taken along the line 21B-21B of Figure 21A, Figure 21C is an end view thereof, Figure 21D is an interior side elevational view thereof, and Figure 21E is a top view thereof; Figures 22A-E are views of a second portion of the cover assembly of Figures 20A-D wherein Figure 22A is an interior side elevational view thereof, Figure 22B is an end view thereof, Figure 22C is a view taken along the line 22C-22C of Figure 22A, Figure 22D is an exterior side elevational view thereof, and Figure 22E is a view taken along the line 22E-22E of Figure 22A;

Figures 23A-C are views of the modular jack mounted on the circuit board of Figures 20A-D wherein Figure 23A is a side elevational view thereof, Figure 23B is an end view thereof, and Figure 23C is a top view thereof; and

Figures 24A-E are views of the circuit board of Figures 23A-C wherein Figure 24A is a first side view thereof, Figure 24B is an end view thereof, Figure 24C is a second side view thereof, Figure 24D is a schematic of the electrical connections thereof, and Figure 24E is a schematic of the electrical connections of an optional 2-pair test adapter;

Figures 25A-C are plots of performance data for the block of US Patent n° 5,044,979 as a function of frequency wherein Figure 25A is a plot of attenuation thereof, Figure 25B is a plot of NEXT thereof, and Figure 25C is a plot of return loss thereof;

Figures 26A-C are plots of performance data for the AT&T 110T-50 block as a function of frequency wherein Figure 26A is a plot of attenuation thereof, Figure 26B is a plot of NEXT thereof, and Figure 26C is a plot of return loss thereof;

Figures 27A-C are plots of performance data in accordance with the present invention as a function of frequency wherein Figure 27A is a plot of attenuation thereof, Figure 27B is a plot of NEXT thereof, and Figure 27C is a plot of return loss thereof.

Referring first to Figures 1A-C, a wiring block in accordance with the present invention is shown generally at 100. Wiring block 100 comprises a base 102 having a mounting bracket 104 snap lock mounted onto one surface thereof. A circuit board 106 is snap lock mounted onto bracket 104. A plurality of connecting blocks 108 are mounted on circuit board 106 along two rows 110 and 112. The connecting blocks 108 are shown in Figure 5 herein and are described in detail in EP-A-0585731, filed 18 August, 1993. While only two rows of connecting blocks 108 are shown in Figures 1A-C, it is contemplated by the present invention that any number of connecting block rows may be em-

ployed with an appropriate base. A plurality of connecting strips 114 are mounted on circuit board 106 along a row 116 between rows 110 and 112.

Referring to Figures 2A-B, base 102 includes an upper surface 118 with a plurality of longitudinally extending channels 120 therein. Each channel 120 has a plurality of rectangular openings 122 therethrough. Retaining ledges 123 (Figure 1B) are defined within openings 122 for retaining bracket 104 on base 102. At each end of base 102 in alignment with each channel 120 is an upright member 124. Upright members 124 each comprise a member 126 and includes a perpendicular notch 132 (Figure 1B) at the lower end thereof. Notch 132 and a slot 130 (Figure 2B) form a cross shaped opening. Also a retaining ledge 134 is defined at the inner facing surface of slot 130. The above features are consistent with a prior art wiring block that is appropriate for use with the present invention. This block, which may or may not be used with the detachable leg assemblies, is described in EP-A-0585700 filed 14 August 1993. Extending from one side of each member 126 is a retaining edge with a co-operating angled surface 136. The retaining edge, surface 136 and member 138 provide means for retaining a designation strip of the type described in EP-A-0585700 designated at 129 in Figure 6 thereof.

Also base 102 has a plurality of mounting holes 140 along the sides thereof. Holes 140 allow for attachment of wiring block 100 to a surface (typically a wiring closet wall or panel).

Referring to Figures 3A-E, mounting bracket 104 includes a base member 142 having upper and lower surfaces 144, 146 respectively. A plurality of rails 148, 148' on surface 144 define channels 150. A wall 152 at each end of bracket 104 closes off the ends of channels 150. Side rail 148' includes a plurality of cut outs 154. Each cut out 154 is closed off by a side retaining member 156. Each side retaining member 156 includes a support ledge 158 formed integrally therewith. Rails 148, 148', walls 152 and ledges 158 all extend upwardly from surface 144 the same distance, thereby defining a support surface having channels 150 therein. A plurality of resilient panels 160 extend upwardly from each side 162, 164 of bracket 104. Panels 160 are located along the sides of bracket 104 and between side retaining members 156. Each panel 160 includes upright members 166 connected by an upper member 168. Further, each panel 160 includes an angled surface 170 on member 168 defining a retaining ledge 172.

A pair of longitudinal rails 174 depend downwardly from the lower surface 146 of bracket 104. Each rail 174 is received in corresponding channel 120 of base 102. A plurality of posts 176 extend downwardly from a lower surface 178 of each rail 174. A pair of upwardly and outwardly extending resilient arms 180 depend from opposing sides of the lower most end of each

post 176. Posts 176 and associated arms 180 pass through openings 120 of base 102, wherein arms 176 engage ledges 123 (Figure 1B), thereby retaining wiring bracket 104 on base 102.

Referring to Figures 4A-C, circuit board 106 is shown. Board 106 is a two-sided printed circuit board having a plurality of vias or feed-through holes there-through. Circuit board 106 includes opposing surfaces 182, 184, opposing sides 186, 188 and opposing ends 190, 192. A first row of pads 194 having plated feed-through holes accepts connecting blocks 108 in row 110. Second and third rows of pads 196, 198 having plated feed-through holes accept connecting strips 114 in row 116, and a fourth row of pads 200 having plated feed-through holes accepts connecting blocks 108 in row 112. A fifth row of plated through holes 202 is disposed adjacent the first row of pads 194, with through holes 202 connected to selected pads 194 by circuit traces 204 on surface 182. A sixth row of interconnected plated through hole pairs 206 is disposed adjacent the second row of pads 196, with through hole pairs 206 connected to selected pads 196 by circuit traces 208 on surface 182. A seventh row of interconnected plated through hole pairs 210 is disposed adjacent the third row of pads 198, with through hole pairs 210 connected to selected pads 198 by circuit traces 212 on surface 182. An eighth row of plated through holes 214 is disposed adjacent the fourth row of pads 200, with through holes 214 connected to selected pads 200 by circuit traces 216 on surface 182. Further, pads 194 are connected to corresponding pads 196 by circuit traces 218 on surface 184, and pads 200 are connected to corresponding pads 198 by circuit traces 220 on surface 184.

Sides 186 and 188 of circuit board 106 include a plurality of recesses 222 each being defined by an edge surface 224 terminating in accurate surfaces 226. Recesses 222 align with the cut out portions 154 of bracket 104, when circuit board 106 is mounted on bracket 104, as will be described hereinafter.

Through holes 202, 214 and through hole pairs 206, 210 are positioned and connected to selected through holes 194, 196, 198 and 200, and circuitry 220, 218 is laid out, whereby the above configuration induces a desired capacitance within the circuit.

Couplings between through holes 200 and 214 and between through holes 194 and 202 are designed to offset capacitive imbalance that is caused by connecting blocks 108. Coupling between through holes 198 and through hole pairs 210 and between through holes 196 and through hole pairs 206 are designed to offset capacitive imbalance that is caused by the corresponding rows of connecting strips 114. Since it is preferable to place the compensation means electrically close to the connector being compensated, there are actually four sets of compensation means for each through circuit; two to compensate for connecting blocks 108 and two to compensate for con-

necting strips 114.

Referring to Figure 4D, capacitor designated C5 represents the combined effects of the two sets of capacitive holes that reside on either the input or output side of the circuit. This "distributed" compensation means has the additional benefit of preserving performance, even when the circuit is interrupted for testing or patching. The benefit provided by these capacitive through holes is manifested by comparing the NEXT performance traces of Figures 25B, 26B on one hand and 27B on the other hand. Figure 27B shows that the present invention exhibits NEXT performance that is 8 dB better than that of Figure 25B and 11 dB better than that of Figure 26B. Capacitive coupling between adjacent pairs of connecting block 108 can be expressed as

$$C_{\text{unbalanced at block 108}} = C_1 - C_2.$$

Capacitive unbalance between adjacent pairs of connecting strip 114 (input or output half only) can be expressed as $C_{\text{unbalanced at one half of strip 114}} = C_3 - C_4$. Capacitance required to restore pair-to-pair balance between connecting block 108 and one half of connecting strip 114 can be expressed as $C_5 = C_{\text{unbalance at block 108}} + C_{\text{unbalance at one half of strip 114}} = (C_1 + C_3) - (C_2 + C_4)$.

Referring to Figure 4, circuit traces 220 and 218 are designed in accordance with the impedance enhancement principle shown. Theoretical characteristic impedance (combined elements) can be expressed as: $Z_0T = [L_T/C_T]^{1/2} = [L_{\text{pch}} + L_{100} + L_{1/2 \text{ 114}} / C_{\text{pch}} + C_{108} + C_{1/2 \text{ 114}}]^{1/2}$

First, characteristic impedance required to match that of the twisted pair cable (UTP) (e.g. $Z_0T = 100$ ohms) is selected. Then the total inductance (or capacitance), including printed circuit board traces is determined by theoretical and/or empirical means. The capacitance (or inductance) between tip and ring conductors of connecting block 108 and one half (or side) of connecting strip 114 is determined by theoretical and/or empirical means. The required tip to ring capacitance to achieve an equivalent characteristic impedance of Z_0T through the following relation is calculated: $C_{\text{pch}} = (L_{\text{pch}} + L_{108} + L_{1/2 \text{ 114}}) - Z_0T^2 (C_{108} + C_{1/2 \text{ 114}}) / Z_0T^2$.

Alternatively, inductance may be calculated by a similar technique. Circuit geometry can be varied and/or through holes added to achieve tip-to-ring capacitance of C_{pch} .

Using this technique, either inductance, or capacitance, or both may be varied on the circuit board to provide an input impedance that is matched with the cable to which it is connected for a given range of frequencies. The benefits of this impedance tuning technique are manifested by comparing Figures 25A, 26A to Figure 27A and Figures 25C, 26C to Figure 27C. Although the electrical length of the present invention is significantly greater than that of the prior art block disclosed in US Patent No. 5,044,479, the impedance tuning method taught by the present in-

vention allows it to exhibit more than 7 dB better return loss than Figure 25C at 100 MHz. Comparison to the results of Figure 26C, (a product that has close to the same electrical length) shows that the present invention has more than 19 dB better return loss at 100 MHz. Because less signal energy is reflected back, the attenuation performance of the present invention is also better than that of these prior art blocks as evidenced by Figures 25A and 26A.

Figures 25A-C show worst case attenuation, NEXT and return loss performance data on the block of US Patent No. 5,044,979 as a function of frequency from 1 MHz to 100 MHz based on four adjacent pairs of twisted-pair wires. Although return loss and attenuation performance satisfy Category 5 crosstalk requirements by at least 4 dB (decibels), at 100 MHz the NEXT requirement is 40 dB or greater. This product measures only 35.9 dB at 100 MHz and consistently fails to meet Category 5 NEXT requirements at other frequencies.

Figures 26A-C show worst case attenuation, NEXT and return loss performance data on the AT&T 110T-50 block as a function of frequency from 1 MHz (megahertz) to 100 MHz based on four adjacent pairs of twisted-pair wires. Although return loss and attenuation performance appear to satisfy Category 5 requirements, the NEXT performance of this product falls short of the TSB40 Category 5 crosstalk requirements by at least 7 dB. At 100 MHz the NEXT requirement is 40 dB or greater. This product measures only 32.7 at 100 MHz and consistently fails to meet Category 5 NEXT requirements at other frequencies.

A distinct advantage of the circuitry on board 106 is that separate compensation means is provided between through holes 198 and 200 and between through holes 194 and 196 such that, when the connection between through holes 196 and 198 is interrupted by inserting a patch connector or test adapter into connecting strip 114, the appropriate amount of compensation still exists for the two separate circuits, that now extend between connecting block 108 and connecting strip 114.

For instances, when test access is desired without interrupt capability, it will be appreciated that the printed circuit board traces may optionally be provided between through holes 196 and 198 to permanently bridge the two opposing rows of connecting strips 114.

The advantage of using through holes, as opposed to discrete capacitors or capacitive pads to perform the tuning function that is necessary to achieve a desired level of transmission performance are manifold. Because they require no added components or secondary assembly operations, as do discrete capacitors, the capacitive through holes offer inherent advantages with respect to manufacturing cost as well as product reliability. Also, for circuit boards with the thickness needed to allow mounting of stan-

dard, off-the-shelf components, the magnitude of capacitance per unit area is much greater than that of overlapping capacitive pads on opposing surfaces. This benefit results from the fact that the capacitive coupling for through holes occurs on multiple planes rather than the unidirectional coupling that is characteristic of parallel pads or plates.

It will be appreciated that in an alternate embodiment (not shown), the diameter and spacing of the through holes may change as required by the physical and electrical constraints of the application or industry standard. Also, the pattern and width of the circuitry that forms the grids and the pads may vary according to the requirements of the individual outlet or connector. Thus providing a method of achieving a controlled amount of capacitive coupling between selected circuit paths of a connector which allows reactive imbalance between pairs that is caused by certain outlet wiring schemes and wire connectors to be compensated for, by the printed circuitry and through holes so as to allow a connection device to meet or exceed Category 5 requirements as described hereinbefore.

The benefits of "Category 5" devices are readily appreciated by one of ordinary skill in the art. The most significant being the substantial cost savings in using unshielded twisted pair wire where shielded, co-axial or fiber optic cable has been used in the past due to bandwidth limitations of the UTP.

Referring to Figure 5, each connecting block is described in EP-A-0585731. Connecting (or connector) block 108 is substantially similar to the connecting block shown in Figures 3-8 of US Patent No. 4,964,812 with the important difference residing in the use of the beam contacts 228, which are for example of the type shown at 70 in Figures 5 and 6 of EP-A-0585731, in place of the prior art beam contacts of the type shown at 10 in Figure 1 of EP-A-0585731. The use of beam contacts 228 permits connector block 108 to be mounted directly into through holes 194, 200 (not shown in this Figure) in circuit board 106 and retained therein by press-fit or soldering techniques.

In general, connector block 108 comprises a one-piece housing 230 composed of a suitable insulating material (preferably polycarbonate). Housing 230 is substantially rectangular in shape and includes a plurality of spaced apart teeth 232 and 234 along the length of its upper surface. The remaining details regarding connector 108 are found in great detail in US Patent No. 4,964,812 and EP-A-0585731, and reference should be made thereto for further description. The housing may or may not have stand-off ribs 236 placed along the bottom surface to facilitate solder flux removal for the clip embodiment shown in Figures 2 and 3 EP-A-0585731.

As in US Patent No. 4,964,812, each terminal clip 228 is retained within housing 230 by a pin 238 which

extends through opening 240 of the terminal clip. The connector block 108 is assembled to terminal clips 228 in accordance with a method shown in Figures 6A-6D of US Patent No. 4,964,812 wherein each pin is initially flash moulded to housing 230 and thereafter driven through the housing 230 and opening 240 in a manner described in US Patent No. 4,964,812.

Referring to Figures 6A-D, 7A-G and 8A-D, one of the connecting strips is shown generally at 114. Connecting strip 114 comprises a generally rectangular housing 242 having a top surface 244, a bottom surface 246, sides 248, 250 and ends 252, 254. A plurality of rectangular openings 256 extend from the top surface 244 through to the bottom surface 246. A U-shaped channel 258 extends from end 252 through to end 254. The upper ends of the U-shaped channel terminate in angled surfaces 260. Each opening 256 includes a central portion which is slightly narrower than the upper and lower portions of the opening. The upper portion reduce inwardly at inclined surface 262 to the central portion. The lower portion steps inwardly at surface 264 to the central portion. The bottom 246 of housing 242 includes an inward step along each side 248, 250 thereof, which defines ledges 266. Slots 268 are formed in each corner, at the lower end of each opening 256. The lower end of slots 268 being tapered.

A plurality of vertical slots 270 are defined at the outer surface of side 248. Each slot 270 includes a step 272 which continues downwardly to a ramp surface 274 followed by an angled retaining surface 276. A plurality of corresponding vertical slots 278 are defined at the outer surface of side 250. Each slot 278 includes a ramp surface 280 followed by an angled retaining surface 282 near the lower end of the slot and in alignment with ramp 274 and surface 276. Further, each slot 270 is aligned with a corresponding slot 278.

A plurality of contact 284 are inserted into openings 256. Each contact 284 includes a base portion 286 which comprises a rectangular shaped plate. Plate 286 has a portion thereof cut to form a tab 288 which is bent away from the plate as shown in Figure 8B. Plate 286 also includes an opening 290 therethrough. A tail portion 292 extends from the lower end of plate 286.

The tail portion 292 may comprise any of the new tail portions described in EP-A-0585731. In this example, the tail portion 292 has a shape similar to that of a needle's eye (sometimes referred to as "eye-of-the-needle" and also referred to herein as an eyelet) which comprises an oblong stem (or tail) 294 with an axially aligned, longitudinal inner oblong or lenticular opening 296 through stem 294. The outer opposed edges 298 of stem 294 are coined as described in EP-A-0585731.

A resilient arm 300 extends generally upwardly from plate 286. Arm 300 includes a straight portion 302 extending upwardly at an angle relative to plate-

286 and in a direction opposite the displacement of tab 288. Depending upwardly following the straight portion 302 is an accurate portion 304, having the outer edges 305 thereof coined, in a direction opposite that of the angular offset portion 302. Again depending upwardly following the accurate portion 304 is a second straight portion 306 having tapered corners.

Two opposing contacts 284 are inserted in each opening 256 such that the accurate portion 304 of each of the contacts within an opening is biased against the other. Further, plate 286 of each contact 284 is received in a corresponding pair of slots 268 of housing 242, whereby tab 288 engages surface 264 within opening 256 acting as a stop. Also tab 288 is biased against the inside surface of the corresponding side of housing 242 to retain the contacts within the openings. Openings 256 are sufficient in size to allow deflection of contacts 284 during insertion of a mating component.

Referring to Figures 9A-D, circuit board 106 is shown snap lock mounted onto bracket 104. Circuit board 106 after having been populated with connecting blocks 108 and connecting strips 114 by either press fit or soldered, as described above, is mounted onto bracket 104. Typically one side of circuit board 106 is positioned whereby the side edge of the circuit board 106 is installed by exerting a downward force on that side of the circuit board. This force causes that side edge of the circuit board to engage ramp surface 170 thereby urging corresponding panels 160 to flex outwardly until the circuit board travels past surface 170. At this point panels 160 snap back into an upright position whereby edges 172 engage surface 182 of the circuit board along this side. Alternatively, the circuit board may be positioned on the panels 160 whereby both sides of the circuit board are urged into the bracket as described above for one side. Although, it should be noted that the latter method of insertion is not the preferred method.

When circuit board 106 is fully inserted into bracket 104, surface 184 of circuit board 106 is supported on the upper surface of rails 148, 148' and held there by edges 172. Tail ends 194 and 292 are received in corresponding channels 150, as shown in Figure 9D.

The assembly shown in Figures 9A-D is then inserted into base 102, whereby arms 180 pass through openings 120 of base 102 and engage ledges 123 as described hereinbefore, resulting in the wiring block 100 shown in Figures 1A-C.

While the above description discloses two rows of connecting blocks with one row of connecting strips therebetween, any number of combination thereof may be employed without departing from the spirit of the present invention. By way of example, Figures 10A-C show an embodiment employing two of the assemblies shown in Figures 9A-D designated here at 310 and 312. In this embodiment a base 314 may be

the same as base 102 shown in Figures 3A-B of EP-A-0585700.

Referring to Figures 11A-E, a disconnect plug for separating or blocking selected positions of a connecting strip 114 is shown generally at 316. Plug 316 shown in these Figures will plug four positions, it will be appreciated that a plug can be configured to plug any number of positions or multiple plugs can be used. Plug 316 comprises an inverted U-shaped member 318 having legs 320, 322 and connecting member 324. A pair of opposing spaced apart ribs 326 extend vertically along the interior surface 328, 330 of legs 320, 322 respectively.

Each rib 326 includes a V-shaped notch 332 for engaging surfaces 274, 276, 280 and 282 within slots 270 and 278 of housing 242. Further, ribs 326 are received within slots 270 and 278, thereby aligning plug 316 over the desired positions on the connecting strips. Plug 316 is preferably a single moulded plastic piece. When plug 316 is installed member 334 is inserted between opposing contacts thereby breaking the electrical connection. Member 334 depends downwardly from member 324 between legs 320 and 322. A plurality of braces 336 are provided between members 334 and 324 to support member 334 during insertion. A T-shaped grip 338 depends upwardly from a surface 340 of member 324.

During insertion of plug 316 on connecting strip 114 the ribs 326 slid into slots 270 and 278. The ends of ribs 326 engage arms 274, 280 urging legs 320, 322 outwardly. A continued downward force is applied until the protrusions defined by surfaces 274, 276 and the protrusions defined by surface 280, 282 are received in recesses 332, at which point legs 320 and 322 will snap back inwardly. During this insertion, member 334 is urged between opposing contacts 284 with openings 256, whereby the contacts flex outwardly.

Referring to Figures 12A-D and 13A-E, a connecting strip cover for use with a modular jack assembly (described hereinafter) is shown. The cover comprises two mating assemblies. A first assembly 340 (Figures 12A-D) comprises an upper body portion 342 having a U-shape defined by legs 344, 346 and a connecting member 348. A leg portion 350 extends downwardly from member 348. Body portion 342 includes a U-shaped cavity 352 at a surface 354 of portion 342. Alignment pins 357 extend outwardly from surface 354. Leg portion 350 has a plurality of spaced apart ribs 356 extending vertically along a surface 358 of portion 350. Each rib 356 includes a V-shaped notch 360 for engaging surfaces 280 and 282 within slots 278. Further, ribs 356 are received in slots 278, thereby aligning assembly 340 relative to desired positions on the connecting strip. A second assembly 362 (Figures 13A-E) comprises a rectangular shaped body portion 364 having an outer surface 366, a recessed inner surface 368, and a peripheral raised in-

ner surface 370. Alignment holes 372 are positioned in surface 370 and are receptive to pins 357 of assembly 340. A leg portion 374 extends downwardly from portion 364. Leg portion 374 has a plurality of spaced apart ribs 376 extending vertically along a surface 378 of portion 374. Each rib 376 includes an inward step 380 for mating with surface 272 in slots 280 and a V-shaped notch 382 for engaging surfaces 274, 276 in slots 270. Further, ribs 376 are received in slots 270, thereby aligning assembly 362 relative to desired positions on the connecting strip. A locking member 384 having ramp surfaces 386 extends away from surface 368.

Referring to Figures 14A-C and 15A-D a modular jack 400 is mounted on a circuit board 402. Jack 400 is secured to circuit board 400 by resilient members 404 which are urged into openings 406 of board 402. Further jack 400 includes leads 408 which further secure jack 400 to board 402 and also provide electrical connection thereto. Jack 400 is, for example, commercially available from Steward Stamping, AMP Incorporated (USA) and other manufacturers of modular connectors.

Board 402 includes sides 410 and 412. A first set of plated feed through holes 414 with pads have leads 408 soldered or press-fit therein. A second set of plated feed through holes 416 are provided in board 402. Circuit traces 418 on side 412 and circuit traces 420 on side 410 interconnect holes 414 with holes 416. Circuit traces 422 on side 412 and circuit traces 424 on side 410 interconnect holes 416 with a row of edge contact pads 426 on each corresponding side of the circuit board.

Referring to Figures 16A-D, 17A-D and 18A-D alternate embodiments of circuit board 402 are shown. Circuit boards 402' (Figures 16A-C), 402" (Figures 17A-C) and 402''' (Figures 18A-C) are similar to board 402 with the exception of the actual circuit pattern, the use of edge contact pads on only one side of the circuit board, and the addition of integrally defined capacitive elements to compensate for reactive imbalance of the jack and the edge contacts. These capacitive elements are of the same type described in EP-A-0602484.

By way of example, side 410 of printed circuit board (402', 402", 402''') includes a grid of circuitry 420 connecting to pads 422, having vias or through holes that are interconnected in substantially diagonal patterns which, in turn, are selectively connected to circuit traces in such a way as to introduce shunt (parallel) connections to the individual circuit paths provided between pads 414 and pads 416; each of which function as one side of a capacitive element. Likewise, a second side 412 of printed circuit board (402', 402", 402''') includes a grid of circuitry 424 connecting to pads 426, having vias or through holes that are also interconnected in substantially diagonal patterns which, in turn, are selectively connected to

other circuit traces; each of which function as a second side of a capacitive element. It will be appreciated that the first set of interconnect of pads 422 on side 410 of the circuit board and the second set of interconnect of pads 426 on side 412 of the circuit board are not electrically connected, by that they are spatially arranged on each side of the circuit board in such a way as to generate a desired amount of capacitive coupling between the circuit grids on opposing sides 412, 410 with the circuit board material being the dielectric material of the capacitor.

Again, the advantage of using through holes, as opposed to discrete capacitors or capacitive pads to perform the turning function that is necessary to achieve a desired level of transmission performance are manifold. Because they require no added components or secondary assembly operations, as to discrete capacitors, the capacitive through holes offer inherent advantages with respect to manufacturing cost as well as product reliability. Also, for circuit boards with the thickness needed to allow mounting of standard, off-the-shelf components, the magnitude of capacitive pads on opposing surfaces. This benefit results from the fact that the capacitive coupling for through holes occurs on multiple planes rather than the unidirectional coupling that is characteristic of parallel pads or plates.

It will be appreciated that in an alternate embodiment (not shown), the diameter and spacing of the through holes may change as required by the physical and electrical constraints of the application or industry standard. Also, the pattern and width of the circuitry that forms the grids and the pads may vary according to the requirements of the individual outlet or connector. Thus providing a method of achieving a controlled amount of capacitive coupling between selected circuit paths of a connector which allows reactive imbalance between pairs that is caused by certain outlet wiring schemes and wire connectors to be compensated for, by the printed circuitry and through holes so as to allow a connection device to meet or exceed Category 5 requirements as described hereinbefore.

Referring to Figures 19A-D, jack 400 with circuit board 402 is installed within the cover assembly 340 (Figures 12A-D) and assembly 362 (Figures 13A-E) form a modular jack test assembly 430. Jack 400 is received within the opening of the U-shape body 342 of assembly 340. Members 404 of jack 400 are engaged by member 384 of assembly 340. Assemblies 340 and 362 are connected by inserting pins 357 of assembly 340 into holes 372 of assembly 362, and may be retained therein by a friction fit or a suitable epoxy. Ribs 356 and 376 are engaged in slots 270 and 278 respectively, in the same manner ribs 326 are engaged in the slots, described hereinbefore. When modular jack test assembly 430 is inserted into a connecting strip 114 pads 426 engage contacts 284 thereby pro-

viding electrical contact therebetween. Assembly 430 may be used for testing or at other times when a modular jack connection is desired.

It will be appreciated that the modular jack test

5 assembly may be configured for any number of positions on a connecting strip 114. Assembly 430 shows contact for eight positions. By way of example a four position modular jack test assembly is shown in Figures 20A-D, 21A-E, 22A-E, 23A-C and 24A-E. These Figures are numbered in accordance with the above described embodiment with the addition of a prime, reference being made thereto for a description thereof. The following differences will be noted: holes 416 are not included, the traces connect directly between pads 414' and 426', upper body portion 342' is rectangularly shaped and has a rectangularly shaped cavity 352', and jack 400' is disposed above body portion 342'.

20 All housings, brackets and other components herein with the exception of the circuit boards and the electrical contacts is comprised of a suitable insulating material (preferably polycarbonate).

25 Claims

1. An electrically wiring device having transmission lines connected thereto, comprising:

30 first and second rows (110 and 112) of first connector means (108), said first connector means (108) including a housing (230) having opposed upper and lower ends and a plurality of contacts (228) in said housing extending between said upper and lower ends, each of said contacts (228) including contact means at a first end thereof for said transmission means,

characterised by

35 a circuit board (106) having circuitry thereon, said circuit board (106) having first and second opposing surfaces (182 and 184), opposing sides (186 and 188), and opposing ends (190 and 192), said contacts (228) of said first connector means (108) including at their second end means for connecting to said circuit board (106),

40 a row (116) of second connector means (114), said second connector means (114) including a housing (242) having opposed upper and lower ends and a plurality of first and second contacts (284) in said housing (242) extending between said upper and lower ends, each of said first and second contacts (284) including contact means (300) at a first end thereof and means (292) at a second end thereof for connecting to said circuit board (106),

45 said contacts (228) of said first connector means (108) in said first row (110) being connected by said circuitry on said circuit board (106) to corresponding said first contacts (284) of said

second connector means (114),
 said contacts (228) of said first connector means (108) in said second row (112) being connected by said circuitry on said circuit board (106) to corresponding said second contacts (284) of said second connector means (114),

said contact means (300) on said first and second contacts (284) of said second connector means (114) co-operating to define a defeatable electrical connection between corresponding contacts (228) of said first connector means (108) in said first and second rows (110, 112), and
 said circuitry on said circuit board (106) being configured so as to substantially restore electrical balance to the transmission lines wherein cross talk originating from said first and second connector means is reduced.

2. The device as claimed in claim 1, characterised in that said circuitry includes a plurality of plated through holes (194, 196, 198, 200, 202, 206, 210, 214) being spaced and connected to obtain a desired capacitance for substantially restoring electrical balance to the transmission lines wherein cross talk originating from said first and second connector means (108 and 114) is reduced.

3. The device as claimed in claim 1 or 2, characterised in that said circuit board (106) is comprised of a dielectric material.

4. The device as claimed in any one of claims 1 to 3, characterised in that said contacts (228) of said first connector means (108) comprise insulation penetrating beam contacts.

5. The device as claimed in claim 4, characterised in that each of said insulation penetrating beam contacts (228) comprises a pair of resilient beams.

6. The device as claimed in any one of claims 1 to 5, characterised in that said means for connecting to said circuit board of said contacts of said first and second connector means comprises a solder tail.

7. The device as claimed in any one of claims 1 to 5, characterised in that said means for connecting to said circuit board of said contacts of said first and second connector means comprises a solderless tail (292).

8. The device as claimed in any one of claims 1 to 7, characterised in that said first and second contacts (284) of said second connector means (114) each include a resilient arm (300) extending toward said first end thereof.

9. The device as claimed in any one of claims 1 to 8, characterised by a base (102) having opposing upper and lower surfaces, said circuit board (106) being disposed on said base, said base (102) including mounting means.

10. The device as claimed in claim 9, characterised by a bracket (104) having opposing upper and lower surfaces, opposing sides, and opposing ends, said lower surface (144) of said bracket being attached to said base (102) by first snap lock mounting means, said circuit board (106) being attached to said upper surface (146) of said bracket by second snap lock mounting means.

11. The device as claimed in claim 10, characterised in that said first snap lock mounting means comprises :

a) on said bracket:
 a rail (174) along the length of said lower surface (144),
 a plurality of spaced posts (176) depending from a surface (178) of said rail (174), and
 a pair of resilient arms (180) extending outwardly and upwardly from one end of each of said posts (176) at opposing sides thereof; and

b) on said base:
 at least one corresponding longitudinal channel (120) in said upper surface (118) thereof, wherein said rail (174) of said bracket (104) is received,
 a plurality of spaced holes (122) through said upper and lower surfaces of said base within said channel (120), and
 an opposing pair of retaining edges (123) defined within each of said spaced holes (122), one end of each of said arms engaging said corresponding retaining edge within said spaced holes.

12. The device as claimed in claim 10, characterised in that said second snap lock mounting means comprises on said bracket:
 a plurality of resilient upwardly extending panels (160) disposed at said sides of said bracket (104),
 a plurality of rails (148, 148') extending upwardly from said upper surface (144) of said bracket (104), said rails (148, 148') defining channels (150) therebetween, said rails (148, 148') having upper surfaces collectively defining an upper support surface, and
 a retaining ledge (172) extending from each of said panels (160), wherein said retaining ledges (172) engage said first surface of said circuit board (106) with said second surface of said

circuit board (106) being supported by said support surface.

13. The device as claimed in claim 12, characterised in that

 said bracket (104) further includes a plurality of side retaining members (156) disposed in between said panels (160); and

 said circuit board (106) further includes a plurality of recesses (222) in said sides thereof, said recesses (222) receiving said side retaining members (156).

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14. The device as claimed in claim 1, characterised in that said circuit board (106) further comprises :

 a first row (194) of plated through holes for receiving said contacts (228) of said first row (110) of said first connector means (108);

 a second row (196) of plated through holes for receiving said first contacts (284) of said second connector means (114);

 a third row (198) of plated through holes for receiving said second contacts (284) of said second connector means (114), said third row (198) of plated through holes being adjacent said second row (196) of plated through holes;

 a fourth row (200) of plated through holes for receiving said contacts (228) of said second row (112) of said first connector means (108), said second and third rows (196 and 198) of plated through holes being disposed between said first and fourth rows (194 and 200) of plated through holes;

 said circuitry connecting said first and fourth through holes (194 and 200) to said third through holes (198);

 a fifth row (202) of plated through holes adjacent to said first row (194) of plated through holes;

 said circuitry connecting said fifth through holes (202) to selected said first through holes (194), wherein coupling between said first and fifth through holes (194 and 202) offsets electrical imbalance induced by said second connector means (114) connected to said second row (196) of through holes;

 a sixth row (206) of plated through hole pairs adjacent to said second row (196) of plated through holes;

 said circuitry connecting said sixth through holes (206) to selected said second through holes (196), wherein coupling between said second and sixth through holes (196 and 206) offsets electrical imbalance induced by said first connector means (108) connected to said first row (194) of through holes;

 a seventh row (210) of plated through hole pairs adjacent to said third row (198) of plated

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through holes;

 said circuitry connecting said seventh through holes (210) to selected third through holes (198), wherein coupling between said third and seventh through holes (198 and 210) offsets electrical imbalance induced by said first connector means (108) connected to said fourth row (200) of through holes;

 an eighth row (214) of plated through holes adjacent to said fourth row (200) of plated through holes;

 said circuitry connecting said eighth through holes (214) to selected fourth through holes (200), wherein coupling between said fourth and eighth through holes (200 and 214) offsets electrical imbalance induced by said second connector means (114) connected to said third row (198) of through holes.

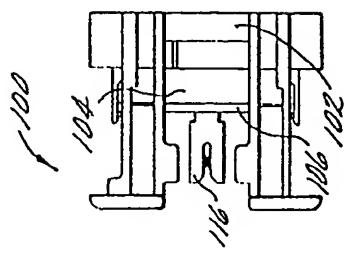


FIG. 1C

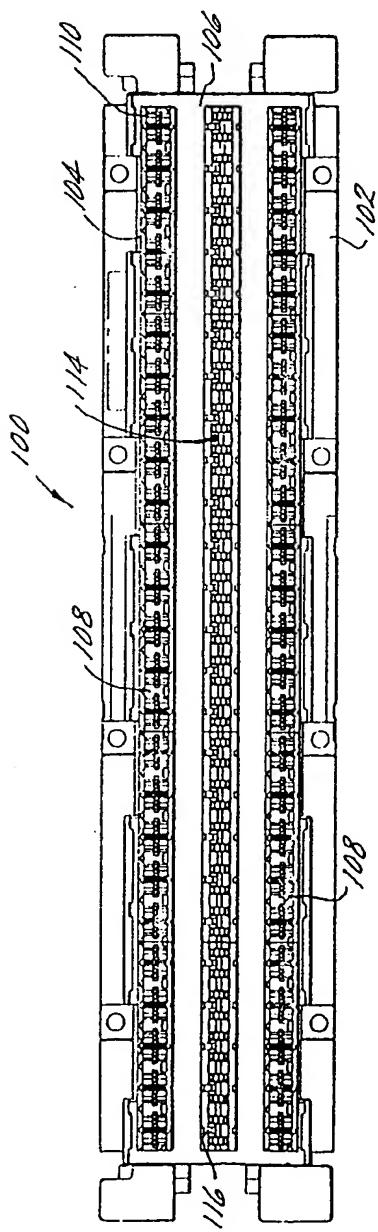


FIG. 1A

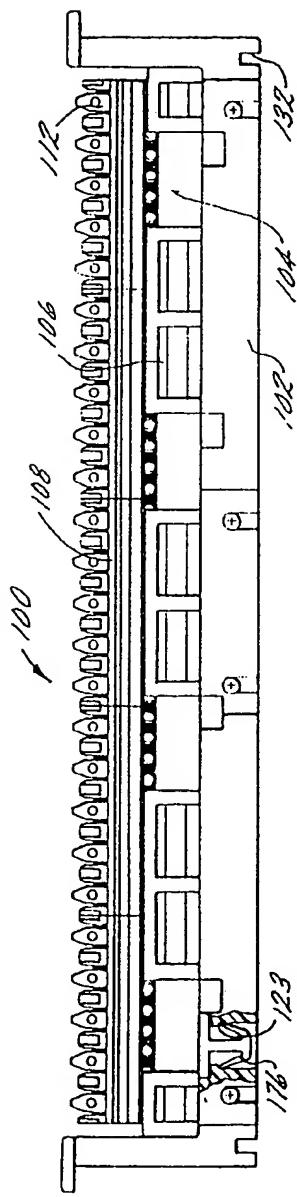


FIG. 1B

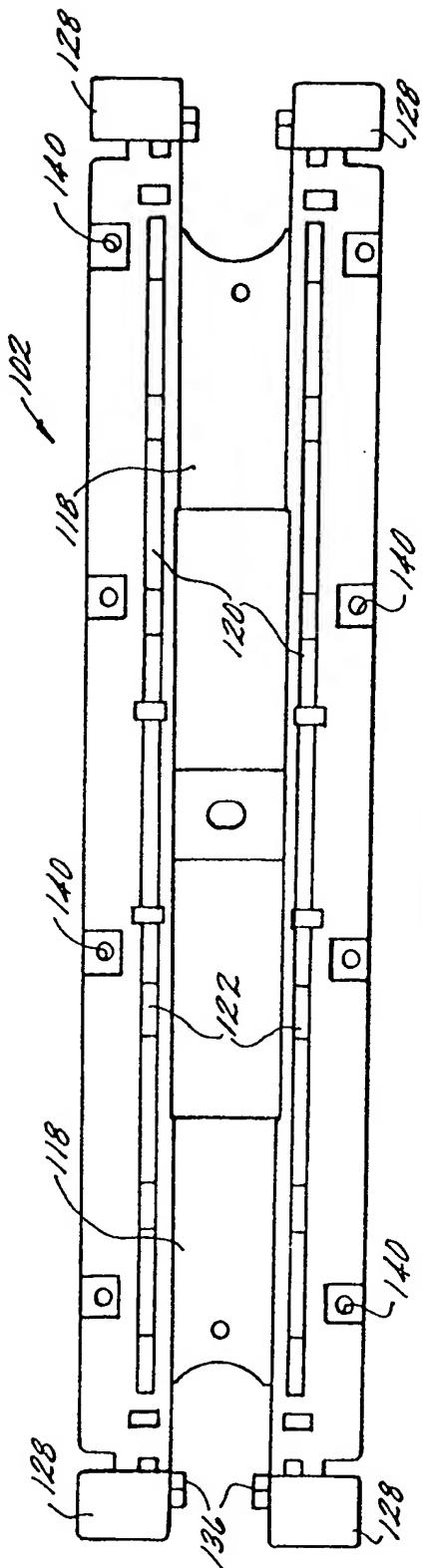


FIG. 2A

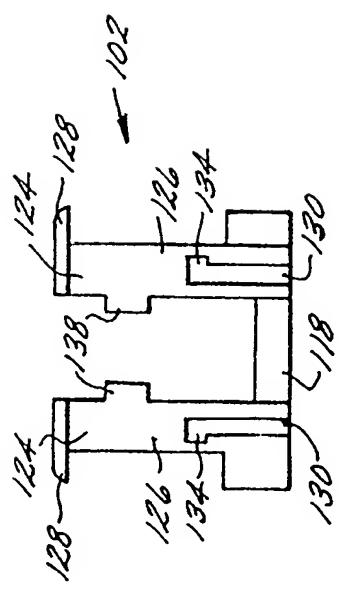


FIG. 2B

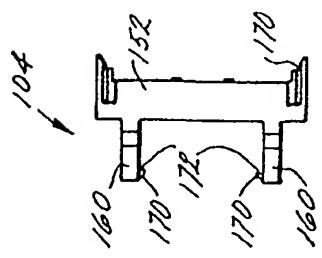


FIG. 3C

FIG. 3A

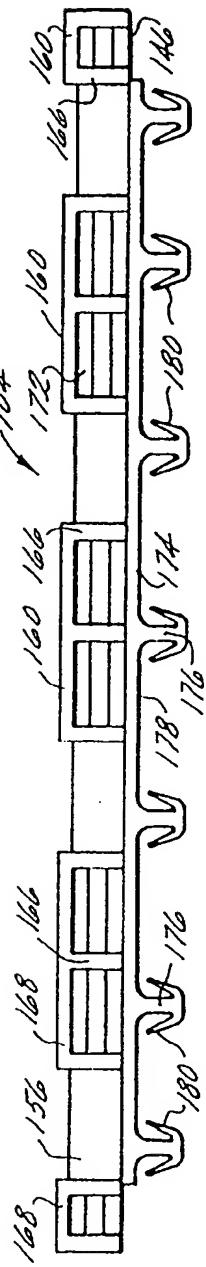
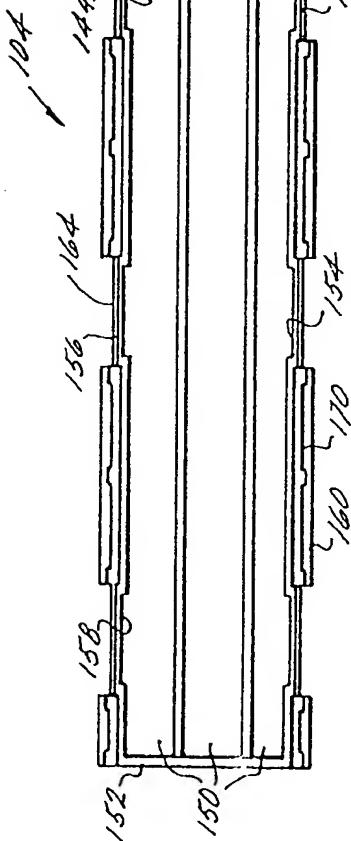


FIG. 3B

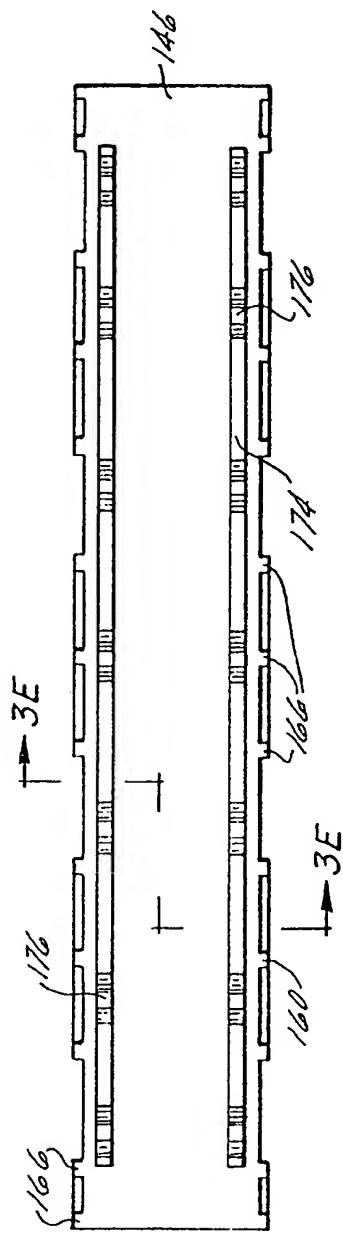


FIG. 3D

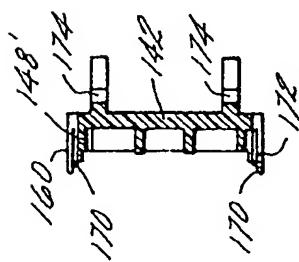
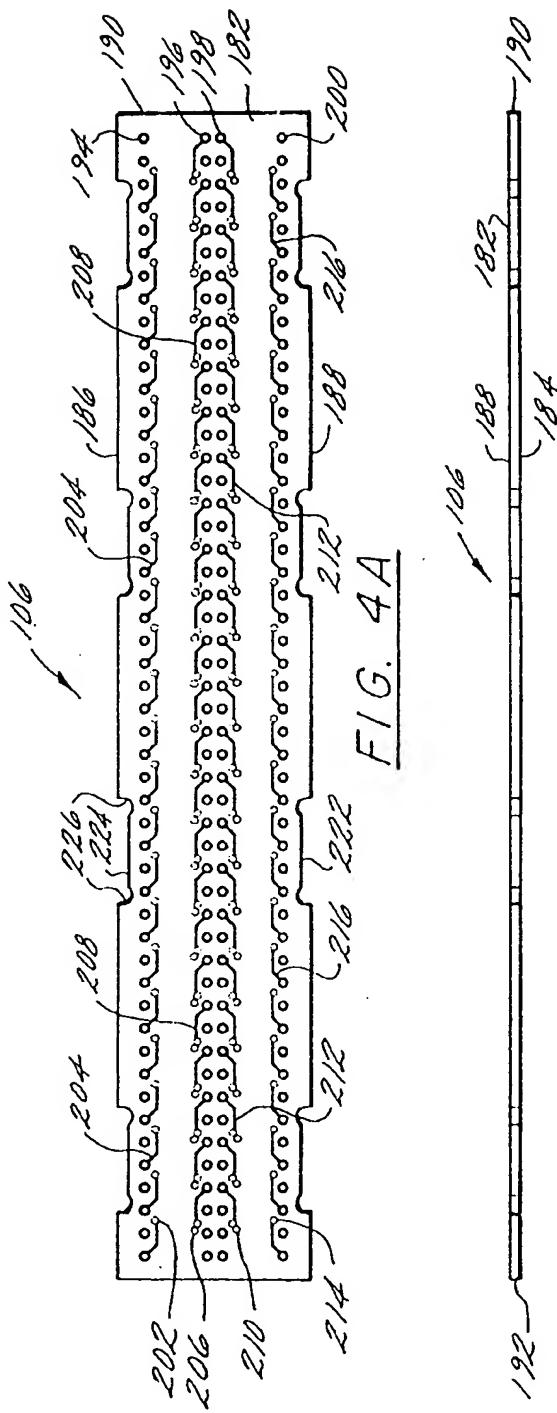
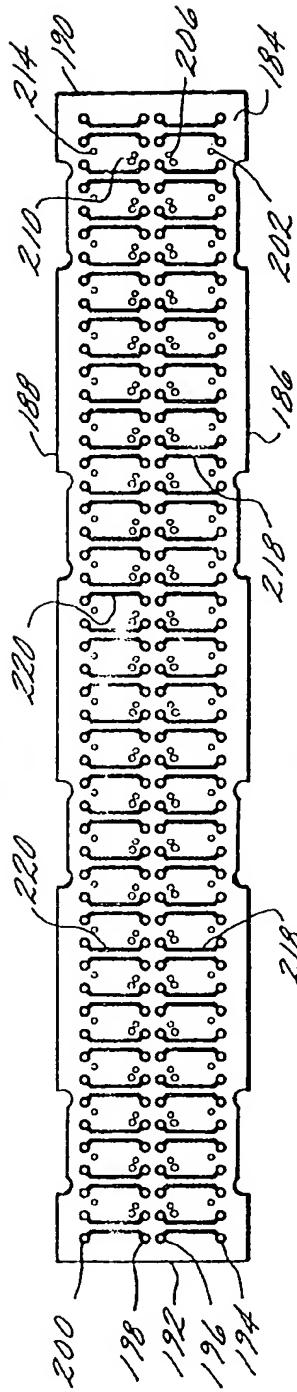


FIG. 3E

FIG. 4BFIG. 4C

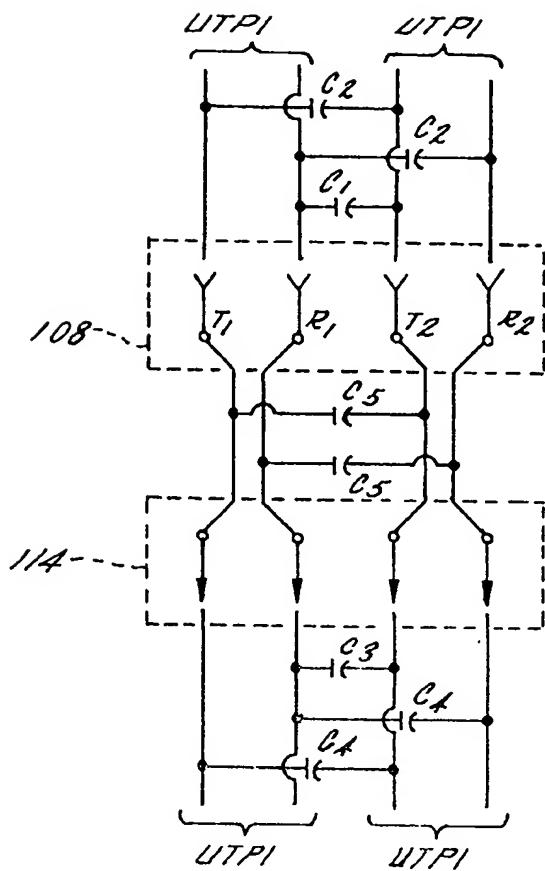


FIG. 4D

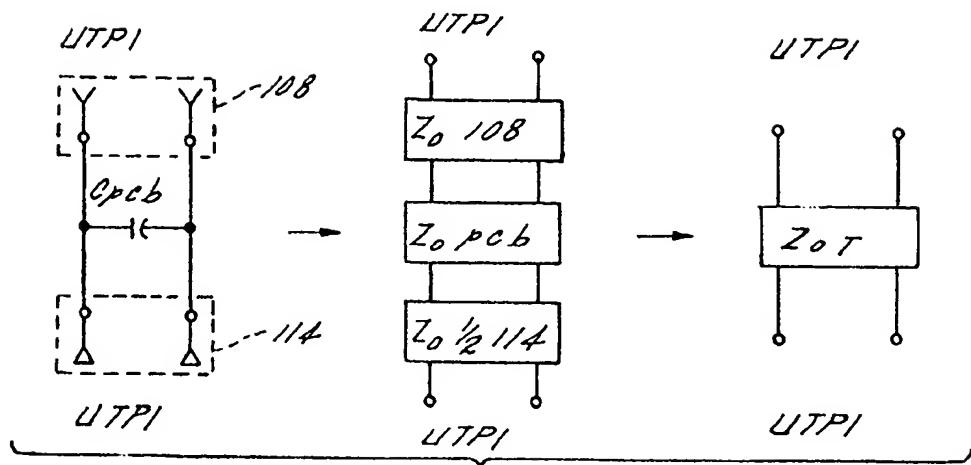


FIG. 4E

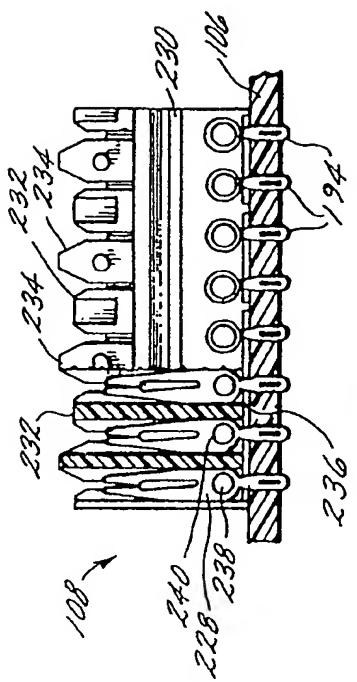


FIG. 5

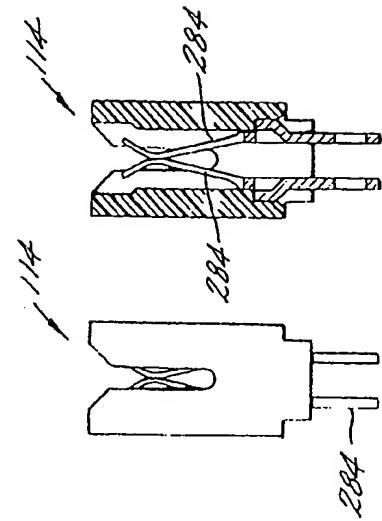


FIG. 6C

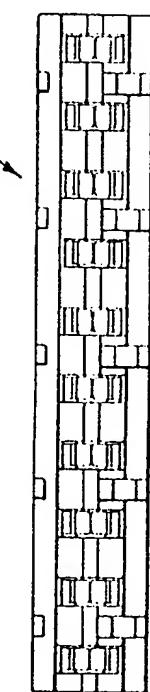


FIG. 6B

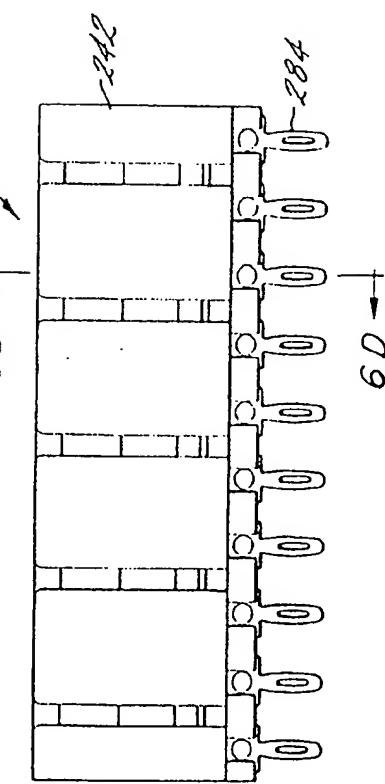


FIG. 6D

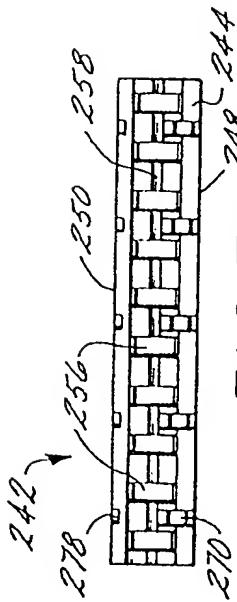


FIG. 7B

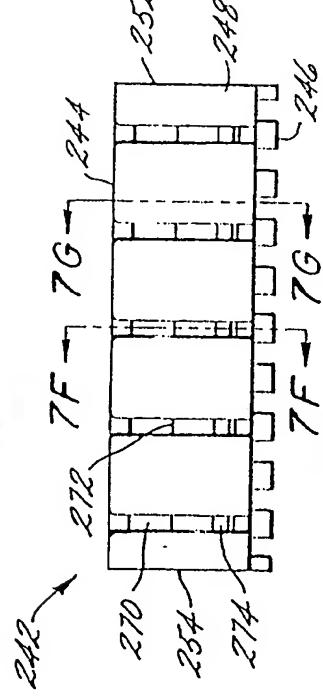
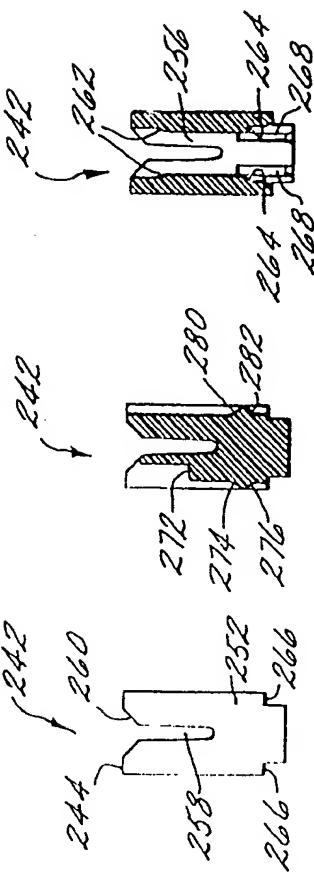


FIG. 7A



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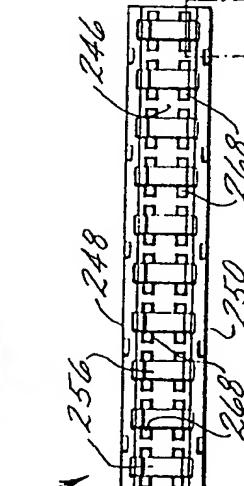


FIG. 7C

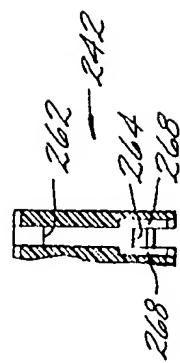
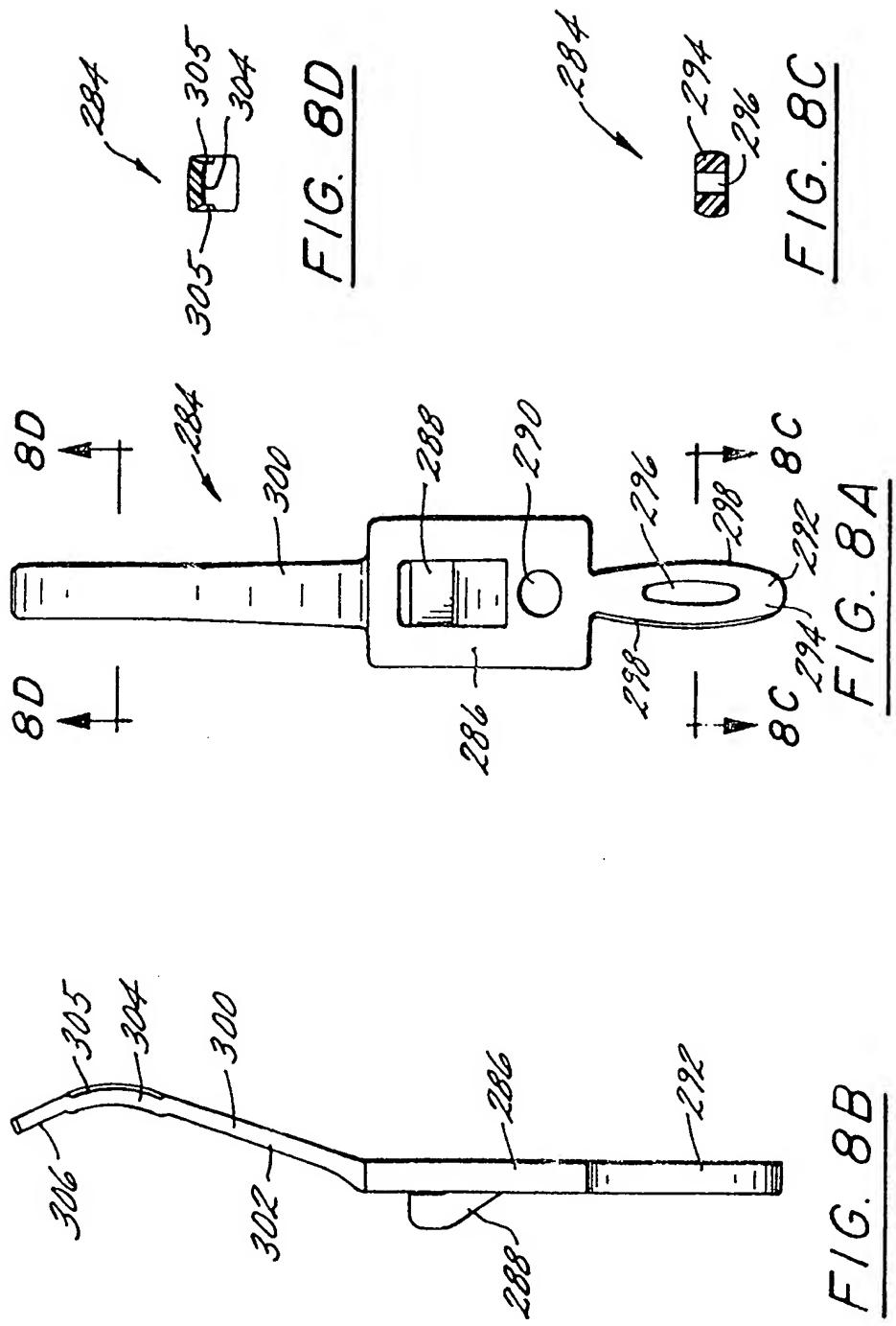


FIG. 7D

FIG. 7G



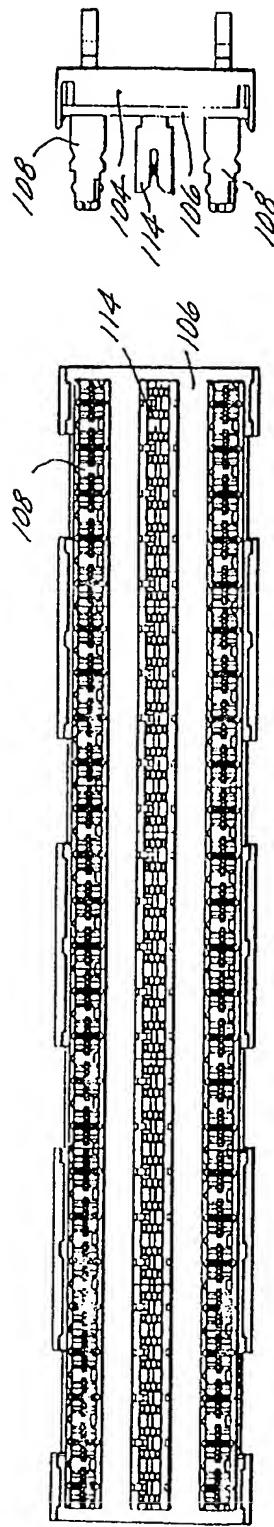


FIG. 9A

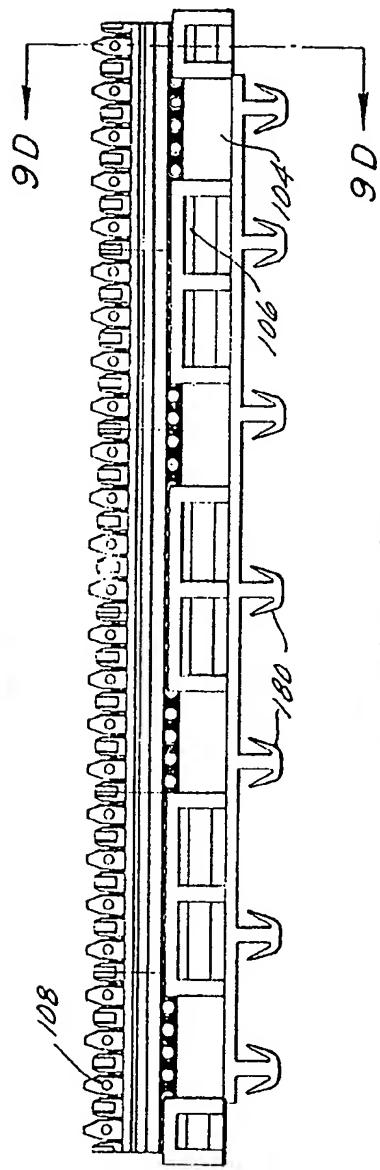


FIG. 9C

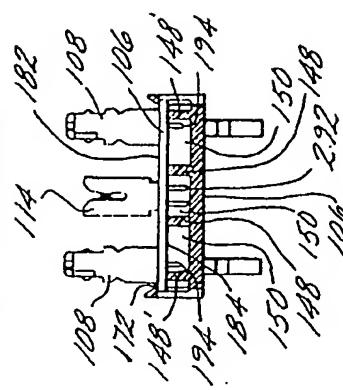


FIG. 9D

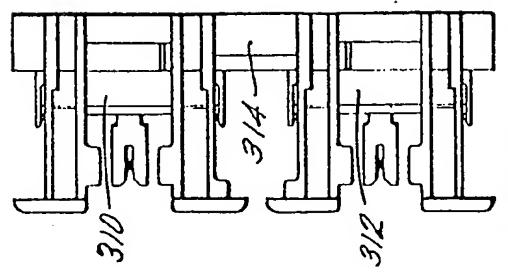


FIG. 10C

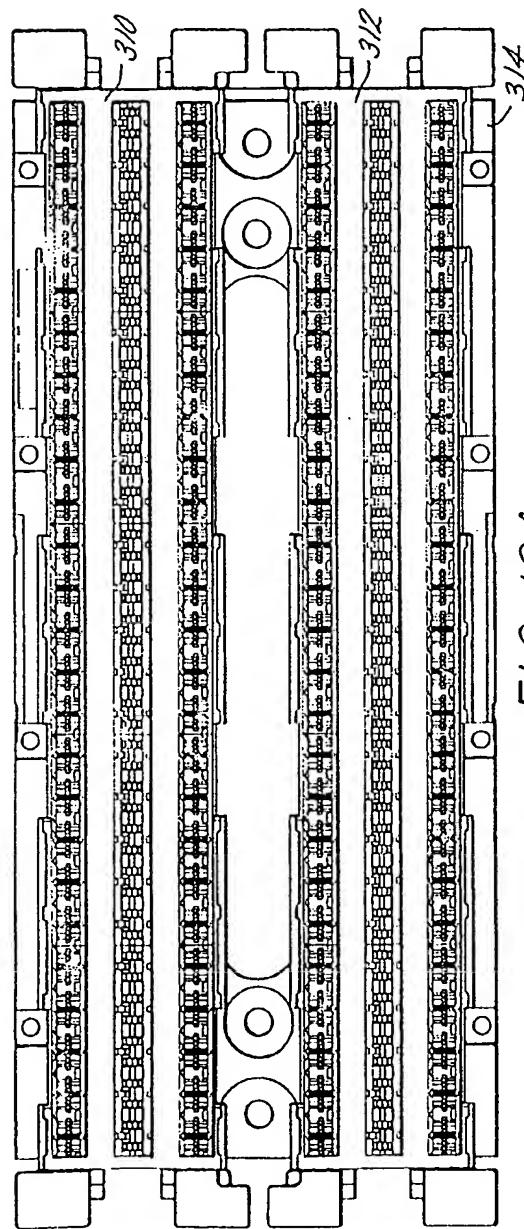


FIG. 10A

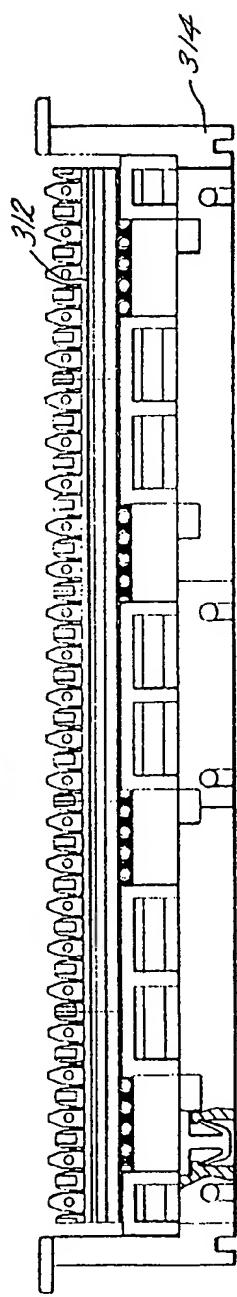


FIG. 10B

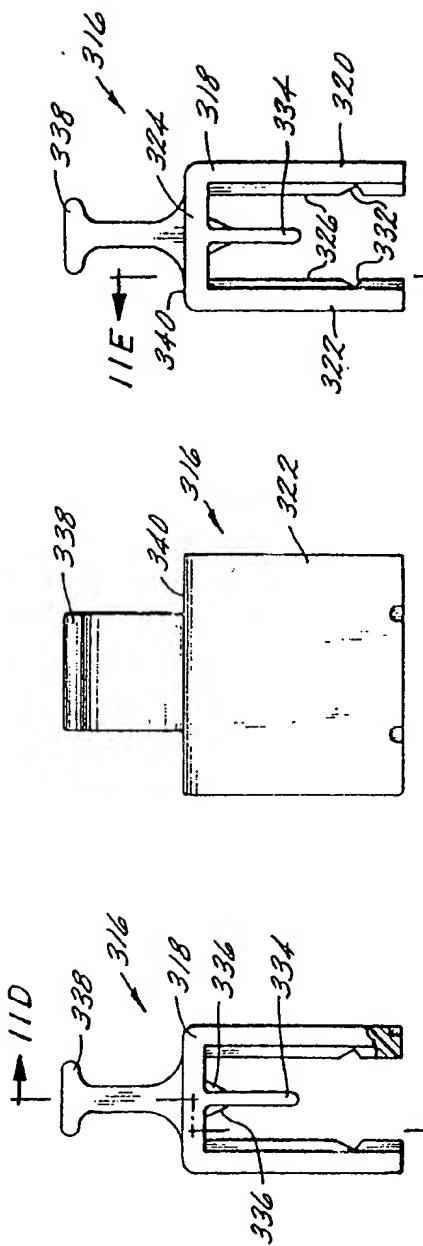


FIG. 11A

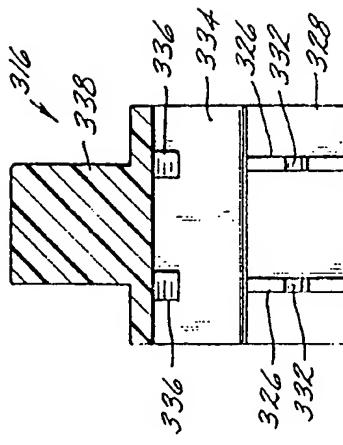


FIG. 11D

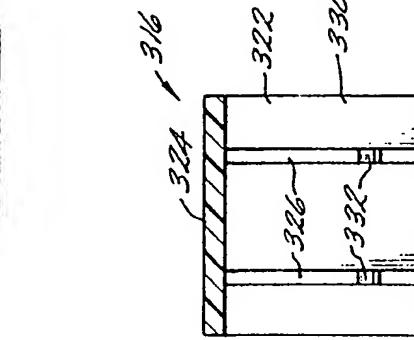


FIG. 11E

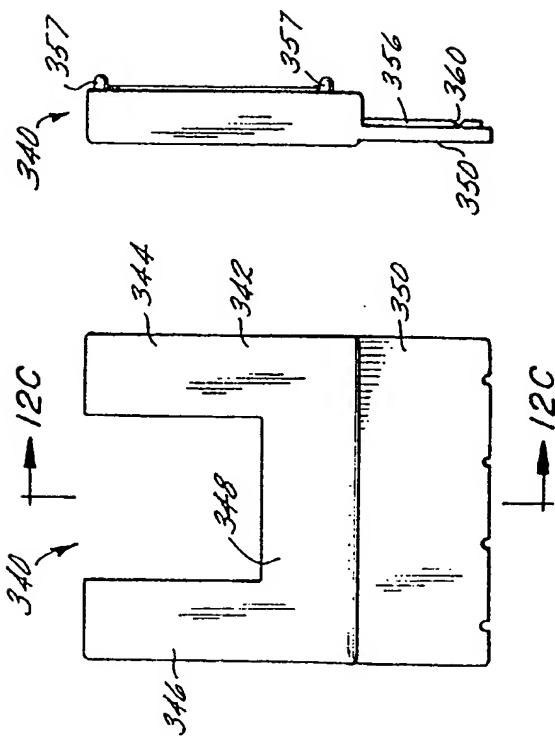


FIG. 12A

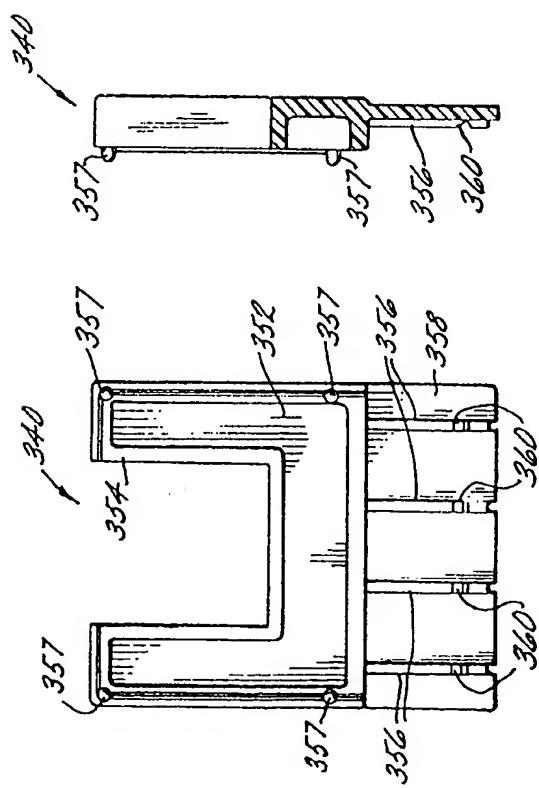


FIG. 12C

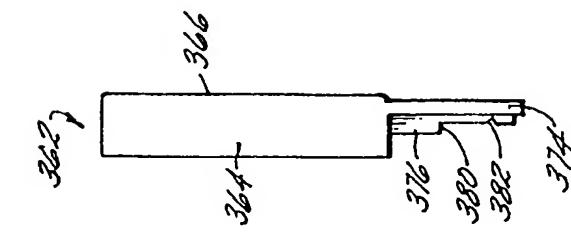


FIG. 13B

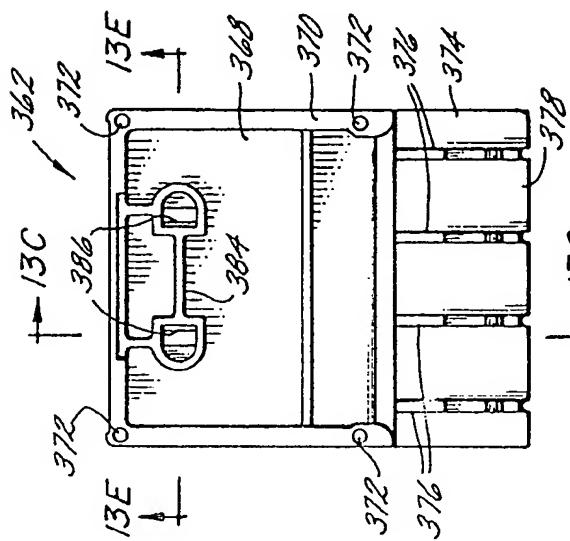


FIG. 13C

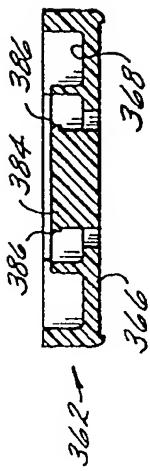


FIG. 13D

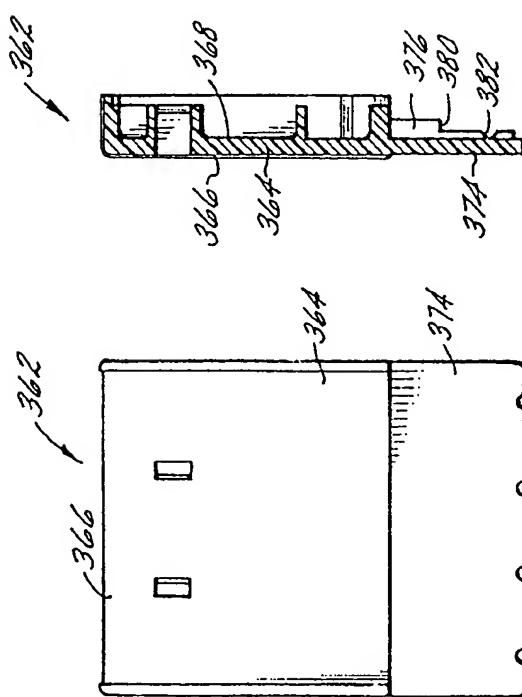


FIG. 13E

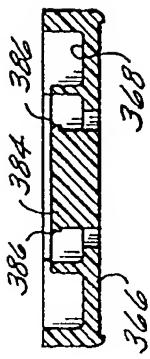


FIG. 13A

FIG. 13E

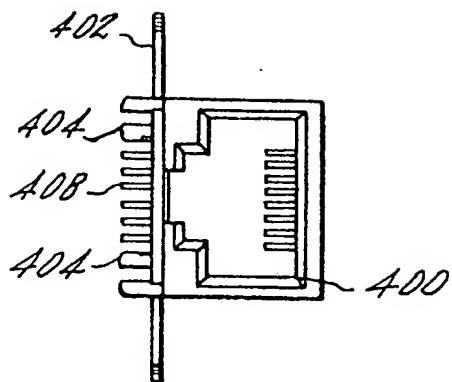


FIG. 14C

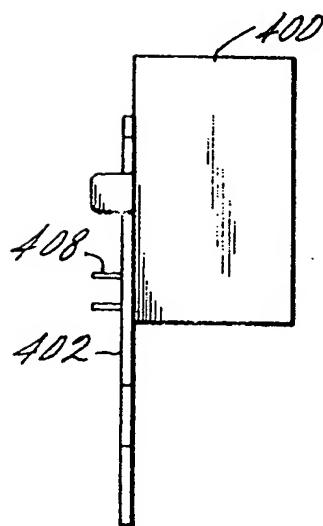


FIG. 14B

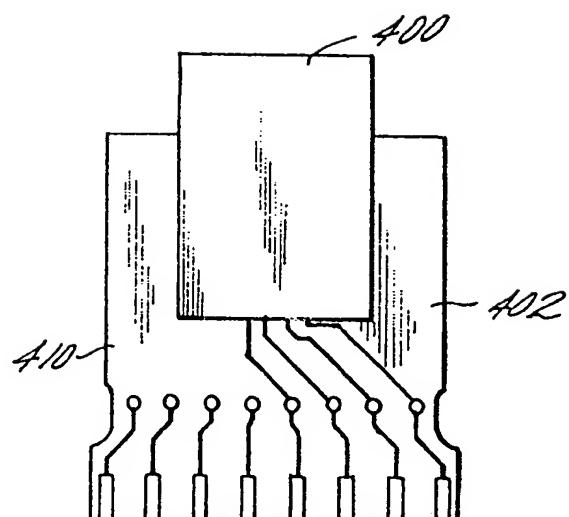


FIG. 14A

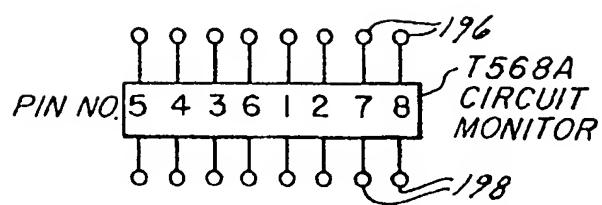


FIG. 15D

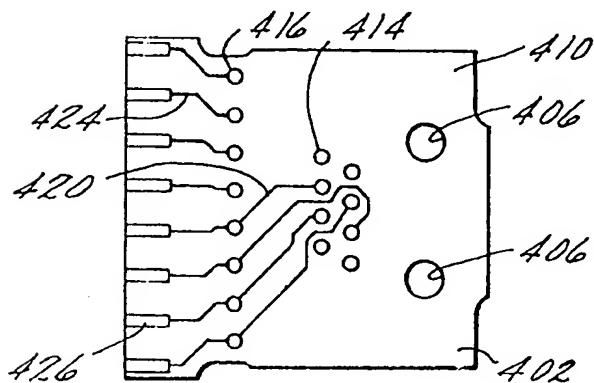


FIG. 15A



FIG. 15B

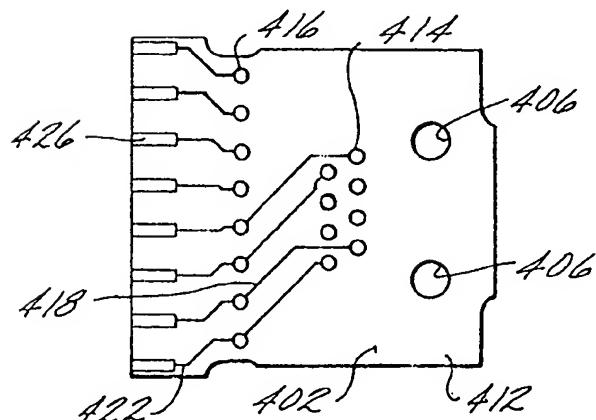


FIG. 15C

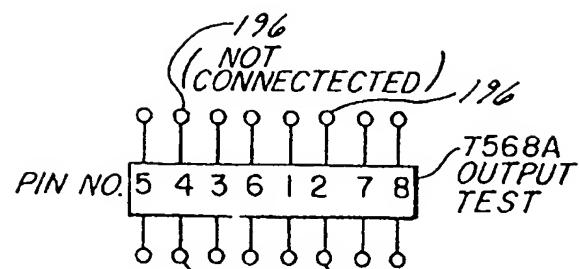


FIG. 16D

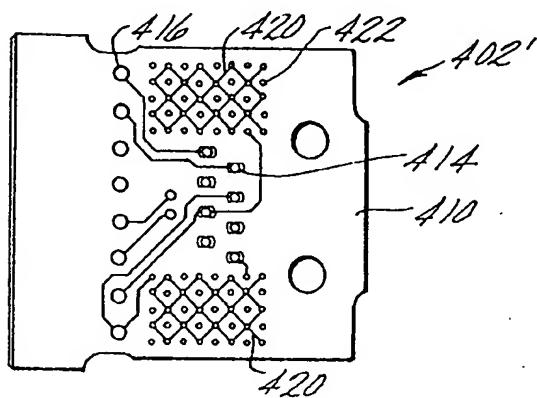


FIG. 16A

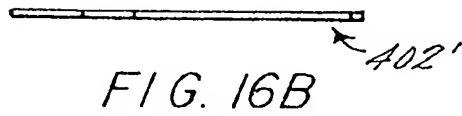


FIG. 16B

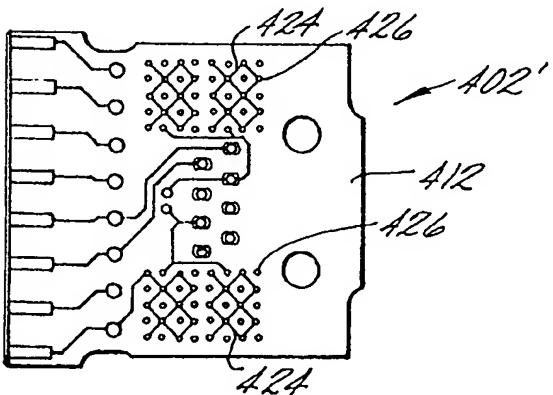


FIG. 16C

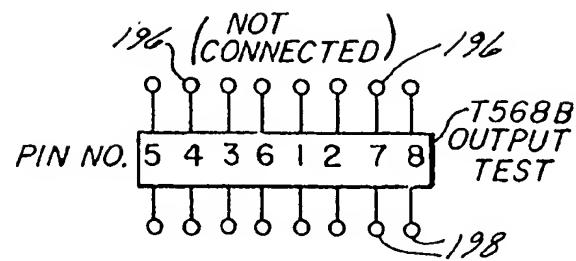


FIG. 17D

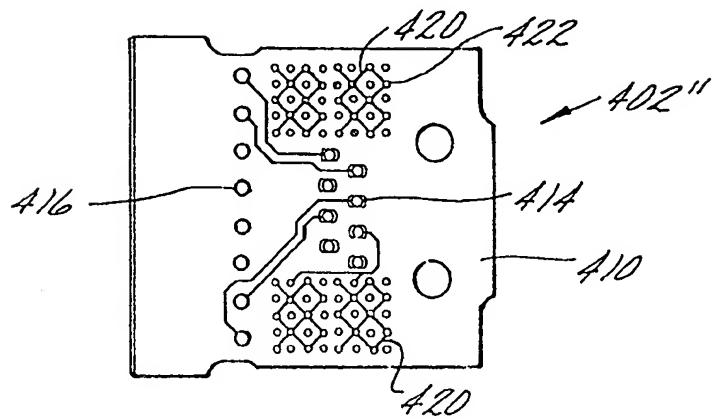


FIG. 17A

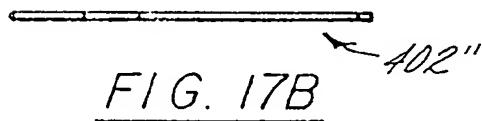


FIG. 17B

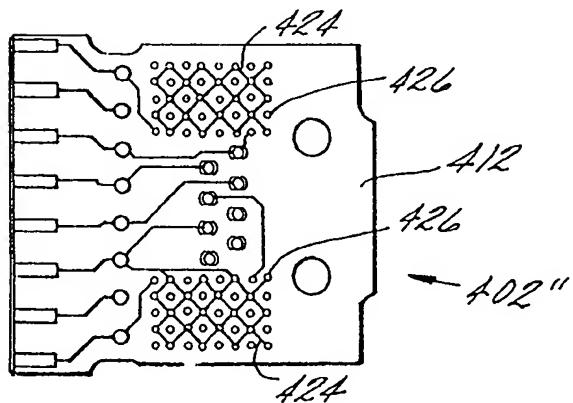


FIG. 17C

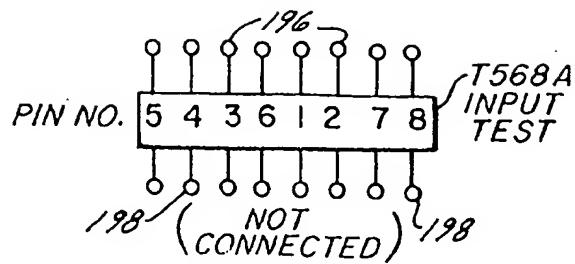


FIG. 18D

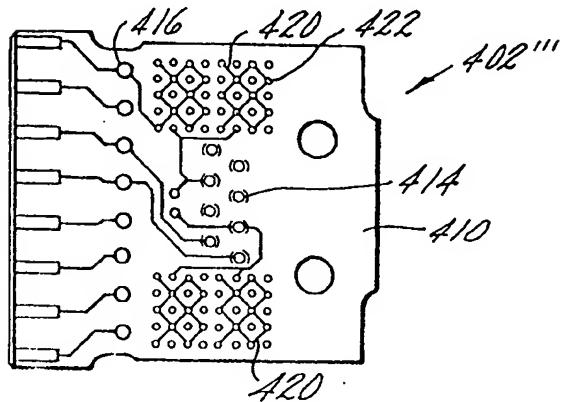


FIG. 18A

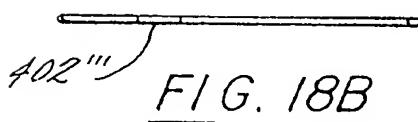


FIG. 18B

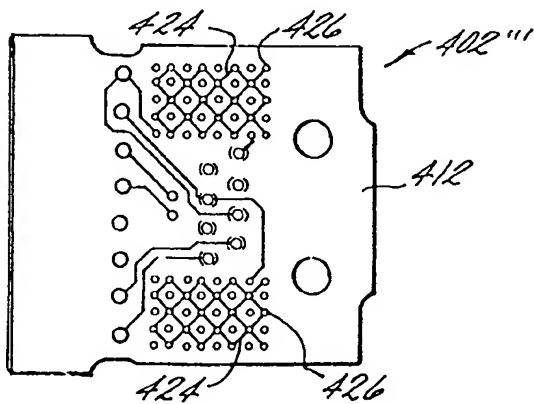


FIG. 18C

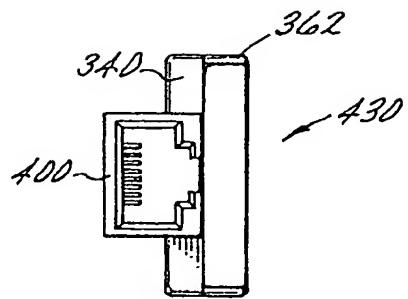


FIG. 19D

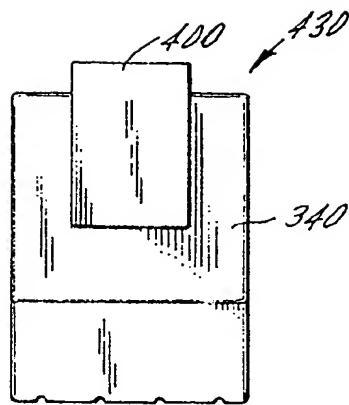


FIG. 19A

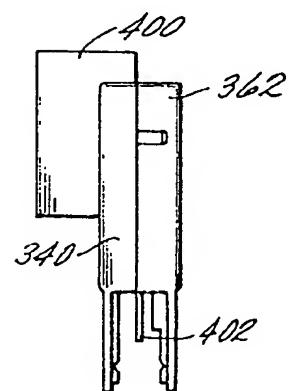


FIG. 19B

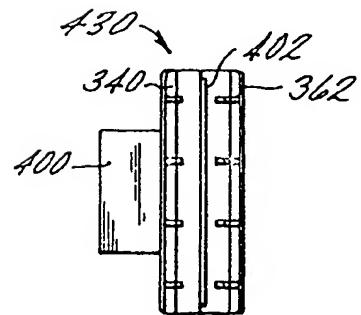


FIG. 19C

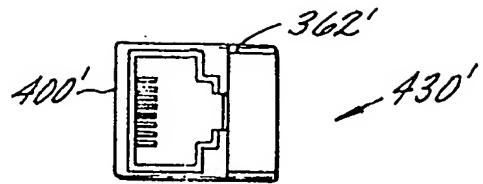


FIG. 20D

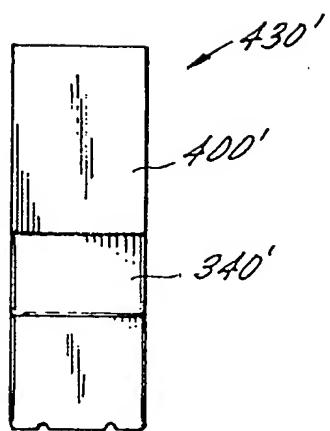


FIG. 20A

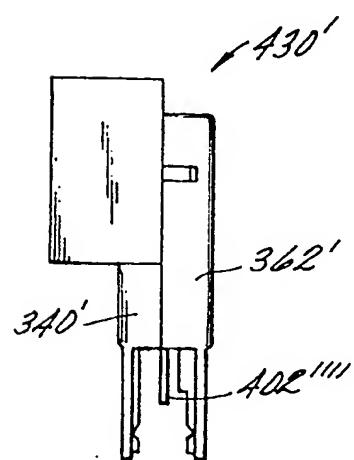


FIG. 20B

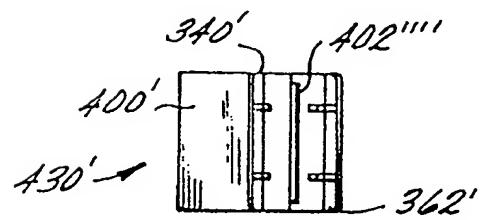


FIG. 20C

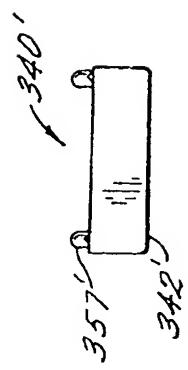


FIG. 21E

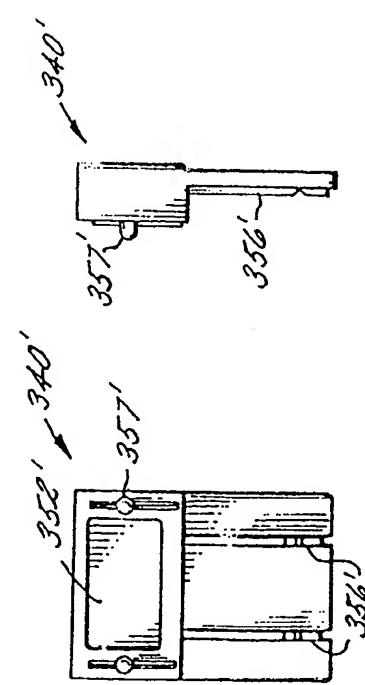


FIG. 21D

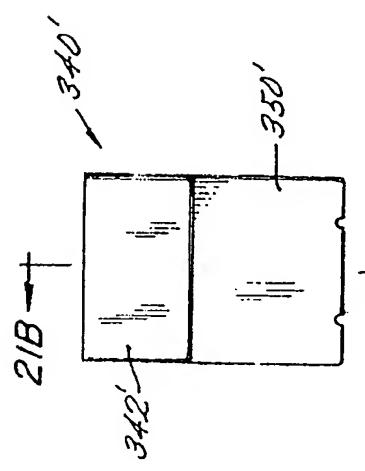


FIG. 21A

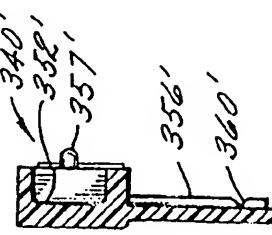


FIG. 21B

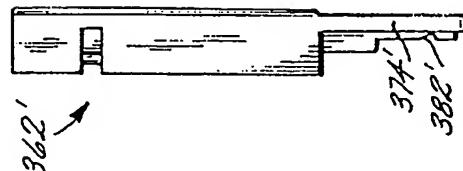


FIG. 22B

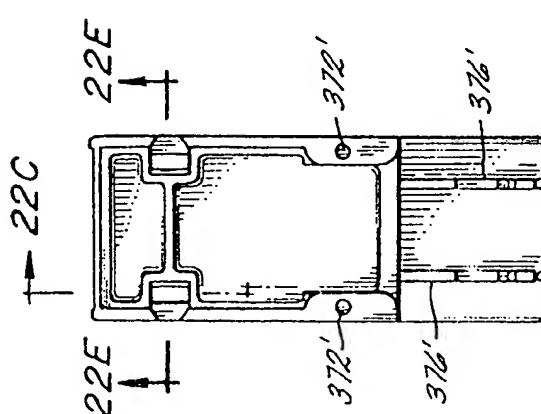


FIG. 22A

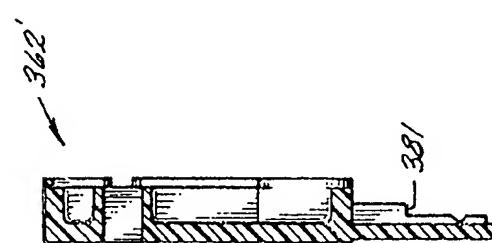


FIG. 22C

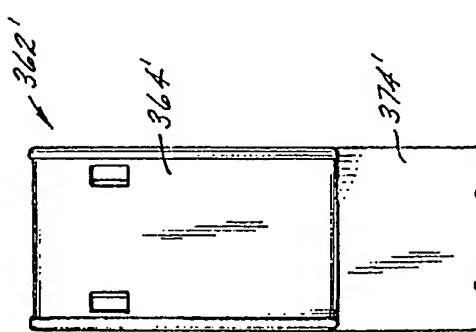


FIG. 22D

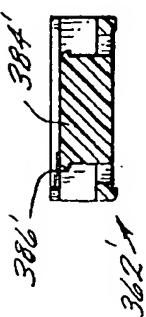


FIG. 22E

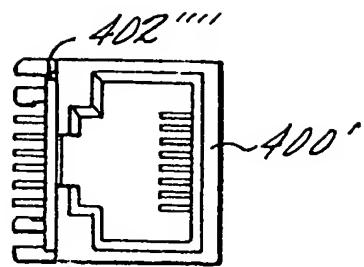


FIG. 23 C

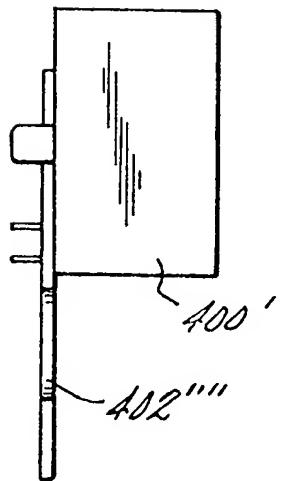


FIG. 23 B

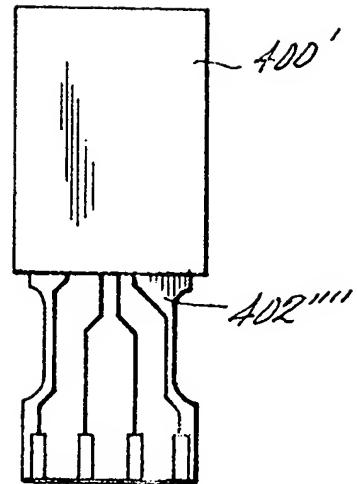


FIG. 23 A

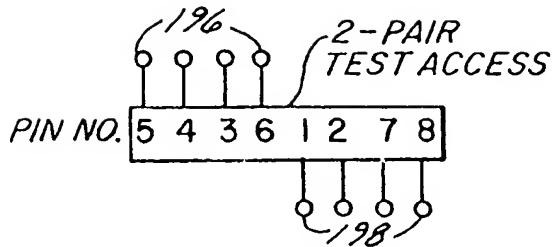


FIG. 24D

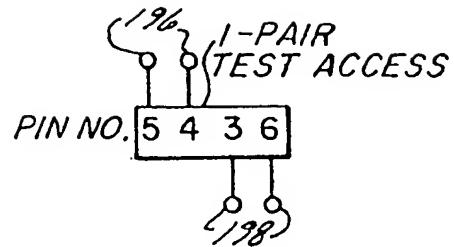


FIG. 24E

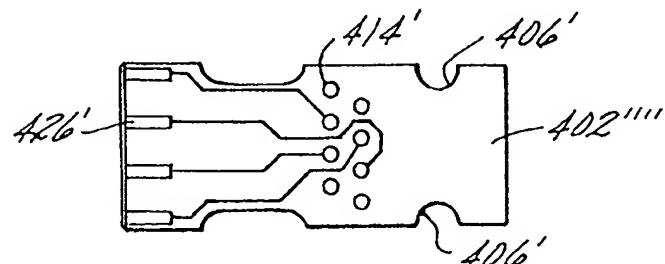


FIG. 24A



FIG. 24B

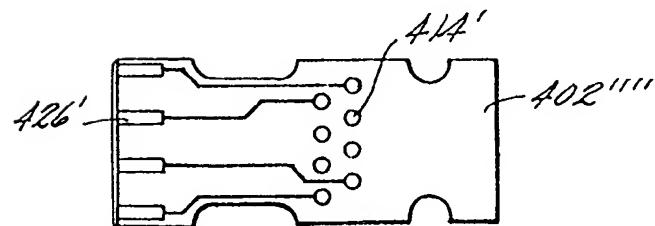


FIG. 24C

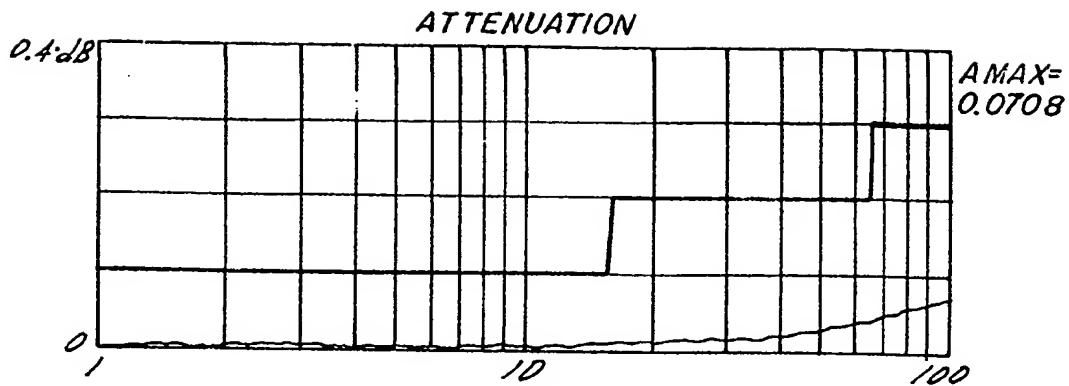


FIG. 25A

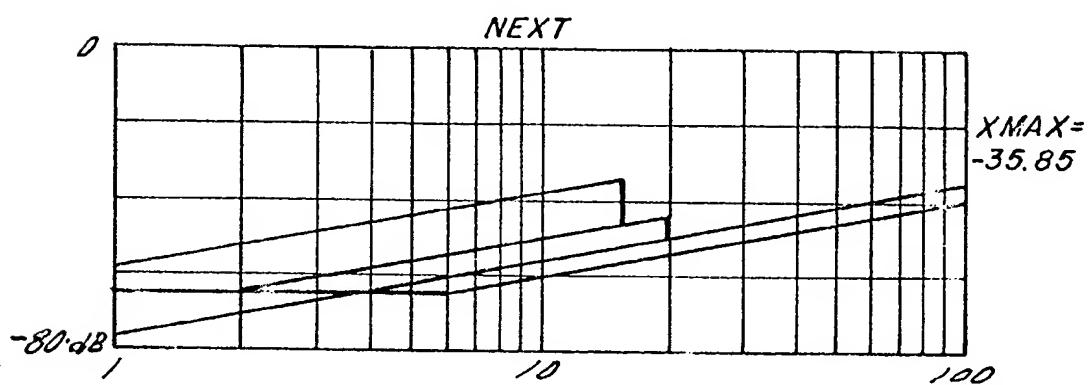


FIG. 25B

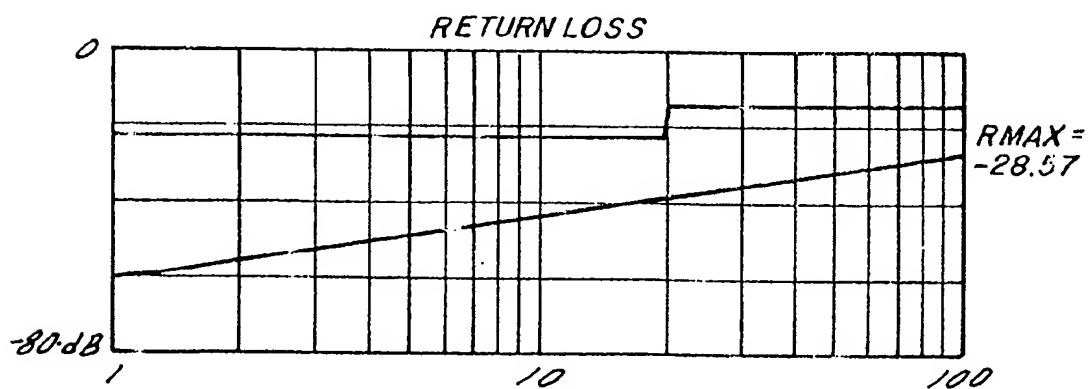


FIG. 25C

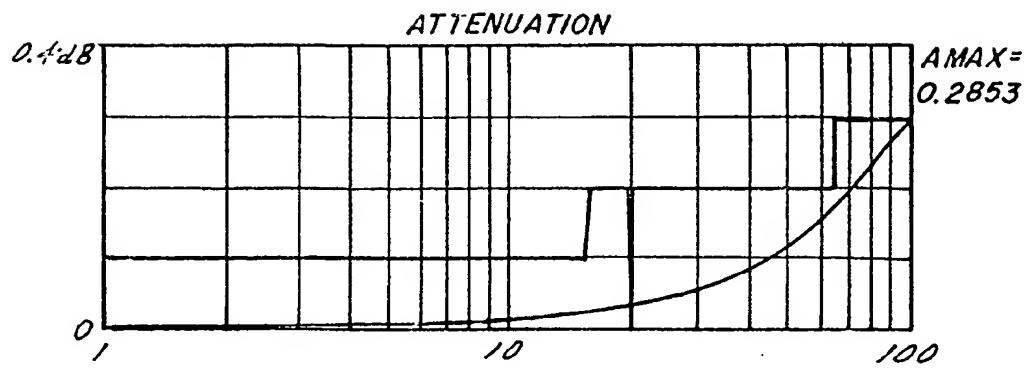


FIG. 26 A

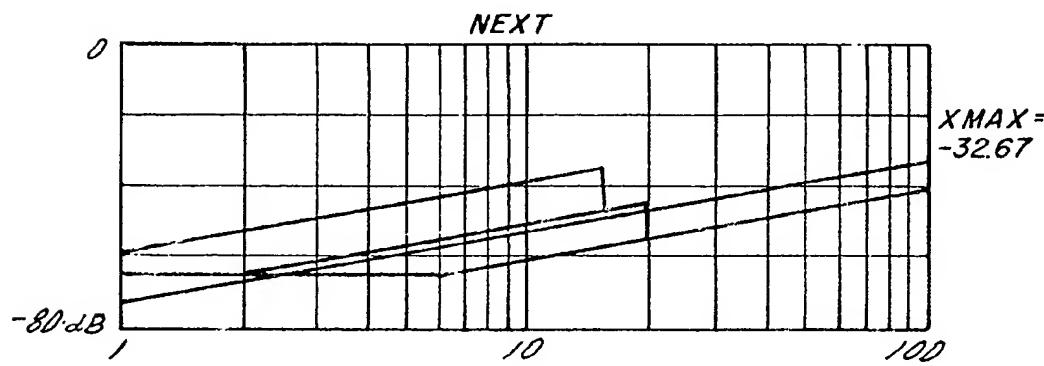


FIG. 26 B

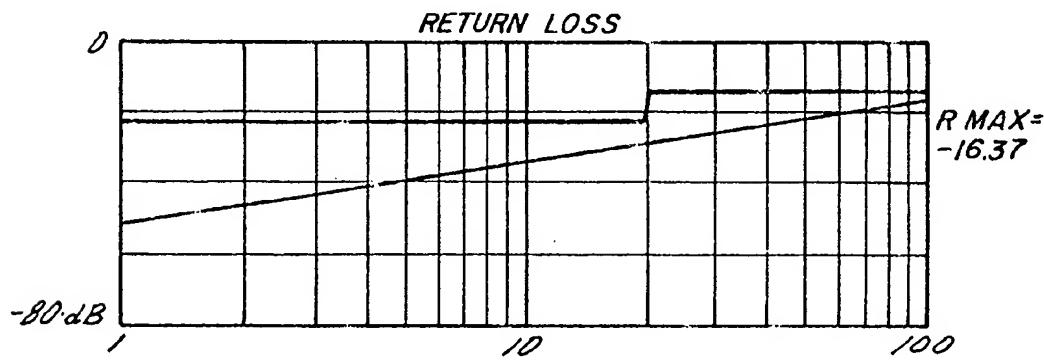
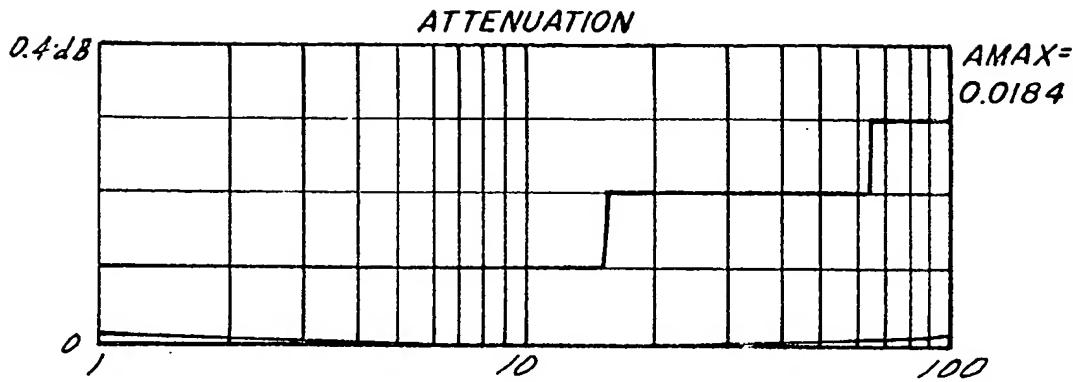
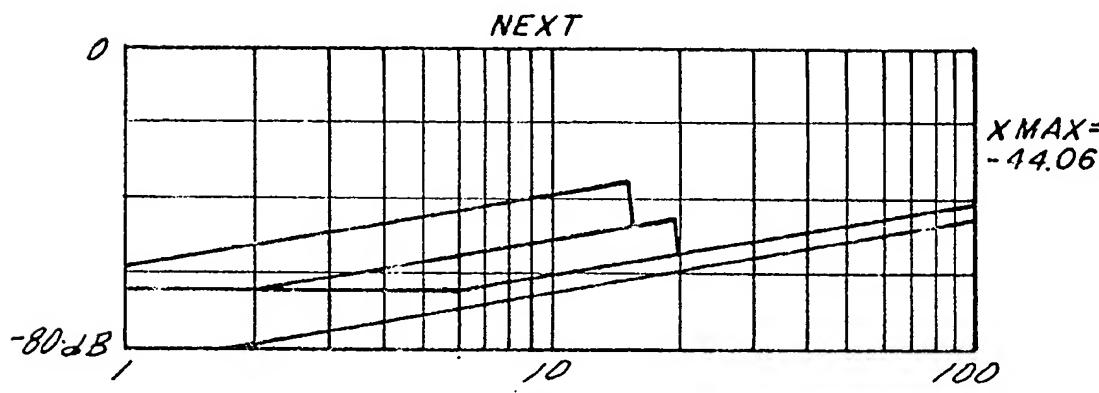
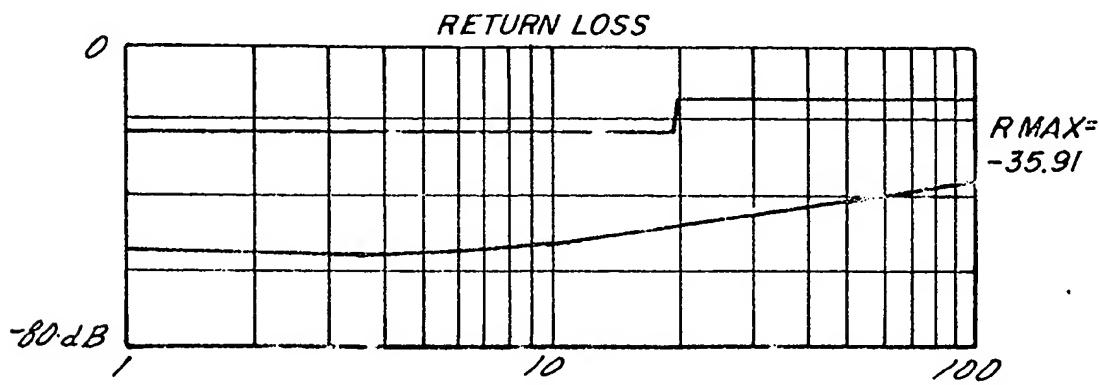


FIG. 26 C

FIG. 27AFIG. 27BFIG. 27C